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Scientific, Technical and Economic Committee for Fisheries (STECF)

Multiannual management plans SWW and NWW (STECF-15-08)

Edited by Ernesto Jardim & Iago Mosqueira

This report was reviewed by the STECF during its 49th plenary meeting held from 6 to 10 July 2015 in Varese, Italy

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Abstract

The STECF was tasked with an analysis of the likely effects of proposed management plans for the Southwestern (Bay of Biscay and Iberia) and Northwestern (Celtic sea) waters. Quantitative analyses were carried out to compare the likely effect of those management plans and of the direct application of the CFP on both stocks and fleets involved in these fisheries. Based on the results of simulations of the provisions of the proposed management plans, STECF concluded that, setting fishing opportunities in line with single-species FMSY ranges will provide managers with additional flexibility compared to the basic provisions of the 2013 CFP. Such flexibility is likely to help alleviate the problem of mismatches in quota availability in mixed-species fisheries thereby reducing the risk of early closure of some fisheries due to choke species. Adopting FMSY ranges will therefore increase the likelihood that desired exploitation rates will be achieved and will reduce the risk that some fishing fleets will go out of business. STECF considers that it is crucial that managers take note that persistent fishing at the upper limits of the FMSY ranges across all or most stocks simultaneously negates the flexibility introduced by the FMSY ranges and greatly increases the risk of overfishing. Such an approach will also increase the risk that the objectives of the CFP will not be achieved. STECF concludes that single species biomass safeguards for all stocks should be maintained to provide a basic level of protection. STECF notes that for the fleets affected by the SWW MAP, those providing the highest employment are generally not dependent to a great extent on the species that will be regulated through the MAP proposals. STECF notes that in the NWW there are some fleets which provide significant levels of employment and seem to be very dependent on the species that will be regulated through the MAP proposals. Nevertheless, there are a number of fleets in the NWW area that are not included in the employment analysis because of an absence of appropriate data. .Regarding the number and scope of MAPs as currently defined, STECF considers that a MAP covering a wider geographic area has advantages in terms of reducing management overheads and avoiding multiple regulations affecting the sector. A larger MAP area however, may have disadvantages associated with reducing the emphasis on local management measures and this may discourage the involvement of stakeholders, although this effect will depend on how the process of regionalization operates within the MAP. To evaluate the question of whether management of the species that drive the fisheries adequately allows for the management of by-catch species, the EWG carried out an analysis of correlations between catches of driver species identified in the plan and a variety of by-catch species. The analysis suggested only limited correlation. In view of this, the STECF notes that it is unlikely that relying on the TAC of the driver species to manage other species will be effective, in accordance with CFP requirements. STECF however notes that when analysis was performed at the fleet level, there were more obvious correlations, suggesting some scope to use fleet related management measures for the driver species as a way of managing some of the bycatch species. STECF therefore concludes that management of exploitation rates of non-driver (or bycatch) species is unlikely to occur as an automatic consequence of the management of the main (driver) stocks by TAC considered in the MAP.

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Multiannual management plans SWW and NWW (STECF-15-08)

THIS REPORT WAS REVIEWED DURING THE PLENARY MEETING HELD IN Varese (Italy), 6-10 June 2015

Background

According to the reformed CFP (Regulation (EU) No 1380/2013), the objective of sustainable exploitation of marine biological resources is more effectively achieved through a multiannual approach to fisheries management, and hence multiannual plans reflecting the specificities of different fisheries shall be adopted as a priority.

Multiannual plans should, where possible, cover multiple stocks where those stocks are jointly exploited. The multiannual plans should establish the framework for the sustainable exploitation of stocks and marine ecosystems concerned, defining clear time-frames and safeguard mechanisms for unforeseen developments. Multiannual plans should also be governed by clearly defined management objectives in order to contribute to the sustainable exploitation of the stocks and to the protection of the marine ecosystems concerned. Those plans should be adopted in consultation with Advisory Councils, operators in the fishing industry, scientists and other stakeholders having an interest in fisheries. Prior to including measures in a multiannual plan, account shall be taken of their likely environmental, economic and social impact.

Request to STECF

STECF is requested to review the report of the STECF Expert Working Group meeting, evaluate the findings and make any appropriate comments and recommendations.

Given the generic approach undertaken for the evaluation of Multi-annual plans associated with the North Western Waters and the South Western Waters Region, the STECF evaluation of the relevant sections (NWW/SWW) of EWG 15-04 and EWG 15-09 are considered together in the following evaluation. STECF evaluation of Multi-annual plans for the Mediterranean (EWG 15-09) can be found in Section **Error! Reference source not found.** of this report.

STECF considerations

STECF notes the considerable amount of work carried out by the EWG and concludes that the different methodologies used to address all the TORs follows the best practices in the field of simulation modelling for providing scientific policy advice.

STECF notes that TORs 3.1 to TOR 3.2 of the EWG 15-04 and EWG 15-09 have been addressed using simulation testing. Five different models have been used to conduct the simulations of the EWG:

- Iberian waters simulation model (FLBEIA).
- Iberian waters multi-fleet state-space model
- Bay of Biscay Spanish fleets simulation model (FLBEIA).
- Bay of Biscay French fleets simulation model (IAM).
- Celtic Sea (FLBEIA)

At the present time, models covering other areas in the NWW (e.g. Irish Sea, Western Channel and West of Scotland) are not available.

Using each of the above models, two management options were simulated. Option one (baseline) which included:

- Single species F_{MSY} objectives
- Achieving objectives in 2016
- Inter-species flexibility (LO)
- Inter-annual flexibility (LO)
- Existing management plans

and option two (named MAP) which when implemented will repeal the existing management plans, includes:

- F_{MSY} ranges instead of single species F_{MSY}
- Achieving objectives in 2016
- Inter-species flexibility (LO)
- Inter-annual flexibility (LO)
- De minimis exemption (LO)
- Survivability exemption (LO)
- Biomass safeguards

The results provided in the EWG Report are expressed in relative terms in order to highlight the relative differences between the two management options.

For most of the stocks concerned, F_{MSY} ranges have not yet been provided by ICES and so were derived using a regression analysis approach based on North Sea and Baltic F_{MSY} estimates (ICES WKFMSYREF3).

The models used were unable to incorporate all fleets and stocks that exist in each of the management areas. However, for the stocks and fleets that could be included in the analysis, the simulations take account of the catches of all stocks and the fleet revenues obtained from them. Furthermore, for the Northern Hake stock, which is common to the two Bay of Biscay simulation models, the parametrization was made consistent and the results obtained from both models were similar.

The potential impact of the LO was not evaluated by the EWG due to time constraints and uncertainty associated with how it is likely to be implemented; namely which decisions will be taken by the MS regarding inter-annual and inter-species flexibilities, which may result in large changes in fishing mortality.

STECF notes that EWG 15-04 and EWG 15-09 used the same method used by EWG 15-04, to highlighted fleets with ‘high’ and ‘low’ employment together with their economic dependency on the species identified in the MAP (relative to the total landings’ value of each fleet). Such an analysis allows the identification of potential employment impacts created by the implementation of the MAP, as well as identifying the fleets most impacted.

All of the EWGs computed a number of economic indicators such as fixed costs, variable costs, revenue and GVA. STECF notes that the forecasts of economic indicators are largely based on the transformation of catch, effort and capacity, and do not reflect other potential economic dynamics due to the due to the difficulties in forecasting changes in prices of fish, costs of fuel, wages, etc. Indicators based on profits are considered to be uninformative and potentially misleading and were deliberately not computed for the reasons outlined in Section 4.1 of the EWG report.

STECF notes that for TOR 3.4 no quantitative analysis was carried out, the EWGs’ findings are based on experts’ knowledge.

STECF notes that TOR 3.5 has been undertaken using correlations between species’ catches. The analyses indicate it is unlikely that setting TACs for the target/driver stocks will be sufficient to manage exploitation rates on by-catch/non-driver stocks.

STECF conclusions

Based on the results of simulations of the provisions of the proposed management plan, STECF concludes that, setting fishing opportunities in line with single-species F_{MSY} ranges will provide managers with additional flexibility compared to the basic provisions of the 2013 CFP. Such flexibility is likely to help alleviate the problem of mismatches in quota availability in mixed-species fisheries thereby reducing the risk of early closure of some fisheries due to choke species. Adopting F_{MSY} ranges will therefore increase the likelihood that desired exploitation rates will be achieved and will reduce the risk that some fishing fleets will go out of business.

STECF considers that it is crucial that managers take note that persistent fishing at the upper limits of the F_{MSY} ranges across all or most stocks simultaneously negates the flexibility introduced by the F_{MSY} ranges and greatly increases the risk of overfishing. Such an approach will also increase the risk that the objectives of the CFP will not be achieved.

STECF concludes that single species biomass safeguards for all stocks should be maintained to provide a basic level of protection.

STECF notes that for the fleets affected by the SWW MAP, those providing the highest employment are generally not dependent to a great extent on the species that will be regulated through the MAP proposals.

STECF notes that in the NWW there are some fleets which provide significant levels of employment and seem to be very dependent on the species that will be regulated through the MAP proposals. Nevertheless, there are a number of fleets in the NWW area that are not included in the employment analysis because of an absence of appropriate data. .Regarding the number and scope of MAPs as currently defined, STECF considers that a MAP covering a wider geographic area has advantages in terms of reducing management overheads and avoiding multiple regulations affecting the sector. A larger MAP area however, may have disadvantages associated with reducing the emphasis on local management measures and this may discourage the involvement of stakeholders, although this effect will depend on how the process of regionalization operates within the MAP.

To evaluate the question of whether management of the species that drive the fisheries adequately allows for the management of by-catch species, the EWG carried out an analysis of correlations between catches of driver species identified in the plan and a variety of by-catch species. The analysis suggested only limited correlation. In view of this, the STECF notes that it is unlikely that relying on the TAC of the driver species to manage other species will be effective, in accordance with CFP requirements. STECF however notes that when analysis was performed at the fleet level, there were more obvious correlations, suggesting some scope to use fleet related management measures for the driver species as a way of managing some of the bycatch species. STECF therefore concludes that management of exploitation rates of non-driver (or bycatch) species is unlikely to occur as an automatic consequence of the management of the main (driver) stocks by TAC considered in the MAP.

REPORT TO THE STECF

EXPERT WORKING GROUPS ON Multiannual management plans SWW & NWW (EWG-15-04 & 09)

Vigo 25-29 May 2015 & Séte 15-19 June 2015

This report does not necessarily reflect the view of the STECF and the European Commission and in no way anticipates the Commission's future policy in this area

1 EXECUTIVE SUMMARY

2 INTRODUCTION

2.1 Background

According to the reformed CFP (Regulation (EU) No 1380/2013), the objective of sustainable exploitation of marine biological resources is more effectively achieved through a multiannual approach to fisheries management, and hence multiannual plans reflecting the specificities of different fisheries shall be adopted as a priority.

Multiannual plans should, where possible, cover multiple stocks where those stocks are jointly exploited. The multiannual plans should establish the framework for the sustainable exploitation of stocks and marine ecosystems concerned, defining clear time-frames and safeguard mechanisms for unforeseen developments. Multiannual plans should also be governed by clearly defined management objectives in order to contribute to the sustainable exploitation of the stocks and to the protection of the marine ecosystems concerned. Those plans should be adopted in consultation with Advisory Councils, operators in the fishing industry, scientists and other stakeholders having an interest in fisheries. Prior to including measures in a multiannual plan, account shall be taken of their likely environmental, economic and social impact.

2.2 Terms of reference

The purpose of the request to STECF is to obtain the scientific grounds for the assessment of the ecological, economic and social effects of a range of possible measures applicable in the context of multiannual plans applicable to demersal fisheries (excluding those for deep-water fish) in:

1) North-western EU waters: subareas VI, VII

2) South-western EU waters: subareas VIII, IX

These multiannual plans will be hereinafter referred to as NWW MAP and SWW MAP respectively.

STECF is requested to analyse the evolution of EU fisheries and to describe their likely situation in the short and medium term in each of the two areas mentioned under two main management options:

Option 1: There are no MAPs; fisheries continue to be managed under the existing rules of the CFP. This includes the existing multiannual plans1, Regulation (EU) 1380/2013 (the Basic Regulation), the Technical Measures Regulation (Regulation (EC) No 850/98) and the Omnibus Regulation (in the process of finalisation at this point in time).

Option 2: In addition to the existing rules, two MAPs enter into force from 2017. The existing MAPs are repealed from 1 January 2017, except the Western Waters Regime2. Under this scenario, STECF will be requested to analyse alternative measures that could be part of the plans.

For each of the scenarios, STECF is requested to run the appropriate forecast models in order to describe the likely situation of the fisheries as in 1 January 2017, 2021 and 2025 using the indicators given below.

2.3 Detailed terms of reference

2.3.1 Basic data and assumptions

Simulations are to be carried out on the basis of the most recent ICES analysis available and on data that exist or that can be collected through the data collection framework (Regulation (EC) No 199/2008). This includes information on population status and dynamics, and reference points, taken as point estimates and, where applicable, ranges of likely values for those reference points. Whenever the later are unavailable, STECF is requested to estimate approximate values just for the purpose of this evaluation, using a simplified methodology on the basis of the same principles as those of ICES (mainly to allow 5% variation in yield and constrain upper limits on the basis of Bpa).

2.3.2 Indicators

2.3.2.1 Biological:

- Abundance (SSB) and fishing mortality relative to Fmsy (F/Fmsy) of main stocks
- Abundance (total biomass) of the main predator stocks. Description of the significance of this indicator in terms of ecosystem status.
- Mean individual size of each of the main species and overall mean individual size of all the main species combined. Description of the significance of this indicator in terms of ecosystem status.

2.3.2.2 Economic (by fleet segment):

- GVA
- Gross cash flow
- Net profit
- Social (by fleet segment):
- Employment and, where possible, associated wages.

2.3.3 Governance

STECF is requested to call the attention to situations where there are difficulties to abide by the rules, leading to is a high probability of non-compliance with law (e.g. "choke" effects potentially leading to discarding or illegal landings). Where STECF believes that measures can be adopted to alleviate the difficulties for the industry (improved selectivity, quota swapping) these should be described.

2.3.4 Detailed scenarios

Scenario under option 1:

Setting of TACs: For all stocks with an analytical assessment and a catch forecast (ICES categories 1 and 2), TACs are proposed in accordance with Fmsy (point estimates) or proxies to it, but in reality it can be expected that TAC reductions beyond 15% will not be finally adopted and that in 30% of the cases Fmsy will be exceeded by a significant margin. For stocks without a full analytical assessment (ICES categories 3 and beyond) TACs will be rolled over.

The landings obligation (LO) applies to all demersal fish subject to quota regulations from 2018 on. This is a knife-edge approximation to a gradual phasing in of the LO from 2016 to 2019. In the absence of MAPs, the landing obligation applies strictly, without exceptions (survivability, *de minimis*, etc).

Only the existing technical measures (Reg. 850/98 and Omnibus) apply. No new rules can be put in place in any other EU legislation. Improvements in selective fishing, e.g. to minimise choke effects or to avoid catch of juvenile fish, might be voluntarily adopted by some fishermen, but then these measures should be taken as less effective (by 50%) than legally binding ones, given they are not expected to be adopted by all vessels. .

Scenario under option 2:

Setting of TACs: Until 2016, TACs will be set as in option 1. From 2017 on, flexibility will be introduced in the Fmsy estimates by the introduction of ranges of Fmsy values consistent with MSY. Decisions in Council are supposed to be on TACs that keep the fishing mortality within Fmsy ranges. Where a stock is or fall below safeguard levels, the strategy would be to rebuild it above such levels in 5 years. Should time permits, STECF is requested to explore the consequences of extending that period to 10 years.

The landing obligation will apply as for option 1, but now the exceptions for survivability and *de minimis* can be applied.

In addition to the existing technical measures, additional measures may be introduced by the regionalisation process in order to minimise choke effects or to avoid catch of juvenile fish. These are to be taken as adopted one year after the entry into force of the plans and are to be considered 100% effective in their intended goals.

2.3.5 Number and scope of MAPs.

While initially two MAPs are conceived for western EU waters (essentially, bounded by the 48°N parallel), STECF is requested to examine the possible advantages and consequences of the following alternatives:

i. A single MAP covering all fisheries operating on the Western EU waters

ii. Separate MAPs covering fisheries in well characterised regions for STECF to determine on the basis of preliminary work already carried out (STECF Report 12-14).

iii. Separate MAPs for the main groups of fisheries, covering all most important fishing activities. Those fisheries would be characterised by a reduced number of target species and a set of by-catch species. The main fisheries, chosen on the basis of work being currently undertaken by Member States on discard plans for demersal species, are set out as an appendix to this document

The above-mentioned exercise is to be based of qualitative expert judgement rather than on mathematical simulations.

2.3.6 Fishery approach

Within the alternative sub-option iii) above, STECF is requested to examine whether setting MSY-compatible TACs uniquely for the target species is sufficient to grant conservation effects on the by-catch species. These conservation effects are to be evaluated against MSY reference points and precautionary stock levels (Bpa) of the by-catch species. Where possible, STECF should explore whether appropriate combinations of F values for target species can be found so the by-catch production is maximised within their Fmsy constraints.

Where managing the target species gives insufficient conservation guarantee to by-catch species, STECF is also requested to assess the possibility of improving the conservation of by-catch species by adopting multi-species by-catch quotas.

2.3.7 List of stocks considered (provided by DGMARE)

A. Stocks for which fishing opportunities are set as part of the NWW MAP

   a. Stocks for which Fmsy ranges can be provided (Cat. 1 and 2):

- Blue ling (*Molva dypterygia*) in Subdivision Vb, and Subareas VI and VII
- Cod (*Gadus morhua*) in Subarea IV (North Sea), Divison VIId (Eastern Channel) and IIIa West (Skagerrak)
- Cod in Divisions VIIe-k (Celtic Sea cod)
- Cod in Division VIIa (Irish Sea)
- Cod in Division VIa (West of Scotland)
- European sea bass (*Dicentrarchus labrax*) in Divisions IVbc, VIIa, and VIId to h (Irish Sea, Celtic Sea, English Channel and southern N,Sea)
- Greenland halibut (*Reinhardtius hippoglossoides*) in Subareas V, VI, XII and XIV
- Haddock (*Melanogrammus aeglefinus*) in Subarea IV and Divisions IIIa West and VIa
- Haddock in Division VIb (Rockall)
- Hake (*Merluccius merluccius*) in Division IIIa, Subareas IV, VI and VII and Divisions VIIIa,b,d (Northern stock)
- Megrim (*Lepidorhombus* spp) in Divisions IVa and VIa
- Nephrops (*Nephrops norvegicus*) in Division VIa (North Minch, FU 11)
- Nephrops in Division VIa (South Minch, FU 12)
- Nephrops in Division VIa (Firth of Clyde + Sound of Jura, FU 13)
- Nephrops in Division VIIa (Irish Sea East, FU 14)
- Nephrops in Division VIIa (Irish Sea West, FU 15)
- Nephrops in Division VIIb,c,j,k (Porcupine Bank, FU 16)
- Nephrops in Division VIIb (Aran Grounds, FU 17)
- Nephrops in Division VIIa,g,j (South East and West of IRL, FU 19)
- Nephrops in the Smalls (FU 22)
- Plaice (*Pleuronectes platessa*) in Division VIId (Eastern Channel)
- Plaice in Division VIIe (Western Channel)
- Sole in Divisions VIIf, g (Celtic Sea)

- Sole in Division VIId (Eastern Channel)
- Sole in Division VIIe (Western Channel)
- Sole in Division VIIa (Irish Sea)
- Whiting (*Merlangius merlangus*) Subarea IV (North Sea) and Division VIId (Eastern Channel)
- Whiting in Division VIIe-k
- Whiting in Division VIa (West of Scotland)
- Haddock in Division VIIa (Irish Sea)

b. Stocks for which only Fmsy proxies can be provided (Cat. 3 and 4):

- Anglerfish (*Lophius budegassa*) in Divisions VIIb-k and VIIIa,b,d
- Anglerfish (*Lophius piscatorius* and *L. budegassa*) in Division IIIaand Subareas IV and VI
- Anglerfish (*Lophius piscatorius*) in Divisions VIIb-k and VIIIa,b,d
- Greater silver smelt (*Argentina silus*) in Subareas I, II, IV, VI, VII, VIII, IX, X, XII, and XIV, and Divisions IIIa and Vb (other areas')
- Haddock in Division VIIa (Irish Sea)
- Ling (*Molva molva*) in Divisions IIIa and IVa, and in Subareas VI, VII, VIII, IX, XII, and XIV ("other areas')
- Megrim (*Lepidorhombus* spp,) in ICES Division VIb (Rockall')
- Megrim (*Lepidorhombus whiffjagonis*) in Divisions VIIb-k and VIIIa,b,d
- Nephrops in the FU 20 (Labadie) and FU 21 (Jones and Cockburn)
- Haddock in Division Vb
- Haddock in Divisions VIIb,c,e-k
- Saithe (*Pollachius virens*) in Subarea IV (North Sea) Division IIIa West (Skagerrak) and Subarea VI (West of Scotland and Rockall)
- Plaice in Divisions VIIh-k (Southwest of Ireland)
- Plaice in Divisions VIIf,g (Celtic Sea)
- Plaice in Division VIIa (Irish Sea)
- Sole in Divisions VIIh-k (Southwest of Ireland)
- Whiting in Division VIIa (Irish Sea)
- Tusk (*Brosme brosme*) in Divisions Ilia, Vb, VIa, and XIIb, and Subareas IV, VII, VIII, and IX (other areas)
- Tusk in Division VIb (Rockall)

c. Stocks for which Fmsy values or proxies cannot be determined (Cat. 5 and 6)

- Pollack (*Pollachius pollachius*) in Subareas VI and VII (Celtic Sea and West of Scotland)
- Saithe (*Pollachius virens*) in Subarea VII

B. Stocks for which fishing opportunities are set as part of the SWW MAP

a. Stocks for which Fmsy ranges can be provided (Cat. 1 and 2):

- Black-bellied anglerfish (*Lophius budegassa*) in Divisions VIIIc and IXa
- White-bellied anglerfish (*Lophius piscatorius*) in Divisions VIIIc and IXa
- Hake in Division IlIa, Subareas IV, VI and VII and Divisions VIIIa,b,d (Northern stock)
- Hake in Division VIIIc and IXa (Southern stock)
- Four-spot megrim (*Lepidorhombus boscii*) in Divisions VIIIc and IXa
- Megrim (*Lepidorhombus whiffiagonis*) in Divisions VIIIc and IXa
- Sole in Divisions VIIIab

b. Stocks for which only Fmsy proxies can be provided (Cat. 3 and 4):

- Anglerfish (*Lophius budegassa*) in Divisions VIIb-k and VIIIa,b,d
- Megrim (*Lepidorhombus whiffjagonis*) in Divisions VIIb-k and VIIIa,b,d
- Nephrops in Divisions VIIIa,b (Bay of Biscay, FU 23, 241
- Nephrops in North Galicia (FU 25')
- Nephrops in West Galicia and North Portugal ("FIT 7,6-77)
- Nephrops in South-West and South Portugal (FU 28-29)
- Nephrops in Gulf of Cadiz (FI J 30)
- Nephrops in the Cantabrian Sea (FU 31)

c. Stocks for which Fmsy values or proxies cannot be determined (Cat. 5 and 6)

- Pollack in Division VIIIab
- Pollack in Division VIIIc
- Pollack in Division IXa
- Sole in Divisions VIIIc and Ixa

2.3.8 *List of fisheries with their target species (provided by DGMARE)*

Table 1. List of fisheries included in the SWW MAP

Area	Species defining the fishery	Fishing gear
VIIIabde	Common sole	OTB between 70-100 mm GTR larger or equal to 150 mm

		BT larger or equal to 70 mm
VIIIabde	Hake	PTB larger or equal to 100 mm OTB larger or equal to 100 mm (20% limit of hake catches)FR LLS GNS larger or equal to 80mm ES 1
VIIIabde	Nephrops	OTB larger or equal to 70 mm*
VIIIc & IXa	Hake	PTB larger or equal to 70 mm*1 OTB larger or equal to 70 mm*1 GNS between 80-99 1 LLS *2
VIIIc & IXa	Nephrops	OTB larger or equal to 70 mm*
IXa	Common sole and plaice	GTR larger or equal 100 mm

*Only applies inside functional units
*1 Only applies to fishing days under effort regime for the southern hake recovery plan FRA
*2 (hook size, conger) ES

Table 2. List of fisheries included in the evaluation of the NWW MAP.

Area	Species defining the fishery	Fishing gear
VIa	Cod, Haddock, Whiting and Saithe	OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, TB, SX, SV, all mesh sizes
VIa	Nephrops	OTB, SSC, OTT, PTB, SDN, SPR, FPO, TBN, TB, TBS, SX, SV, FIX, all mesh sizes
VI, VII	Hake	OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, TB, SX, SV, GNS, GN, GND, GNC, GTN, GTR, all mesh sizes
VI, VII	Hake	GNS, GN, GND, GNC, GTN, GTR, all mesh sizes
VI, VII	Hake	LL, LLS, LLD, LX, LTL, LHP, LHM, all mesh sizes
VII	Nephrops	OTB SSC, OTT, PTB, SDN, SPR, FPO, TBN, TB, TBS, SX, SV, FIX, all mesh sizes
VIIa	Cod, Haddock, Whiting and Saithe	OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, TB, SX, SV, all mesh sizes
VIId	Common Sole	TBB
VIId	Common Sole	OTT, OTB, TBS, TBN, TB, PTB, smaller than 100mm
VIId	Common Sole	GNS, GN, GND, GNC, GTN, GTR, all mesh sizes
VIId	Cod, Haddock, Whiting and Saithe	OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, TB, SX, SV, all mesh sizes
VIIe	Common Sole	TBB, all mesh sizes
VII excl. VIIa; VIId and VIIe for	Common Sole	TBB, all mesh sizes

Common Sole		
VII excl. VIIa; VIId and VIIe for Common Sole	Common Sole	GNS, GN, GND, GNC, GTN, GTR, all mesh sizes
VII excl. VIIa; VIId and VIIe for Common Sole	Cod, Haddock, Whiting and Saithe	OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, TB, SX, SV, all mesh sizes

3 DESCRIPTION OF THE FISHERIES

This section describes the major fleets and stocks of each region with the Western Waters of the European Union, as well as the major oceanographic and geologic characteristics of the area. For more detailed information, refer Annexes I-IV, where a thorough description of the fleets and stocks can be found.

3.1 North Western Waters

The Celtic Seas comprise the shelf area west of Scotland (ICES Subarea VIa), the Irish Sea (VIIa), west of Ireland (VIIb), as well as the Celtic Sea proper (VIIf-k) and western Channel (VIIe).

The variety of habitats in the Celtic Sea accommodates a diverse range of fish, crustacean and cephalopod species that support a wide variety of fisheries targeting different species assemblages. The Celtic Sea groundfish community consists of over a hundred species and the most abundant 25 comprise 99% of the total estimated biomass and around 93% of total estimated numbers (Trenkel and Rochet, 2003). This ecoregion has important commercial fisheries for cod, haddock, whiting and a number of flatfish species. Hake (*Merluccius merluccius*) and anglerfish (*Lophius spp*) are also fished across the whole area. The shelf slope (500-1800 m) comprises a distinct species assemblage, including roundnose grenadier (*Coryphaenoides rupestris*), black scabbardfish (*Aphanopus carbo*), blue ling (*Molva macrophthalma*) and orange roughy (*Hoplostethus atlanticus*), as well as deep-sea squalidae (sharks) and macrouridae. The major commercial invertebrate species is the Norway lobster (*Nephrops norvegicus*), targeted by trawl fisheries throughout the Celtic Sea. Common cuttlefish (*Sepia officinalis*) are also exploited in the Celtic Sea, whilst there is dredging for scallops and smaller bivalves in the western English Channel, Irish Sea and west of Scotland. Pot fisheries take place for lobster (*Homarus gammarus*) and edible crab (*Cancer pagurus*) in coastal areas of this region. The most commonly used gear types in the Celtic Sea are otter trawls, beam trawls, netters, dredges and pots.

The following maps (Figure 1) illustrate the spatial distribution of the catches of main targets species described in the Annex 2 and the catches per gear in the Celtic Sea, based on STECF catch data. Each statistical rectangle is split depending on the proportion of each species/gear catches and their size are proportional to the total amount of catches.

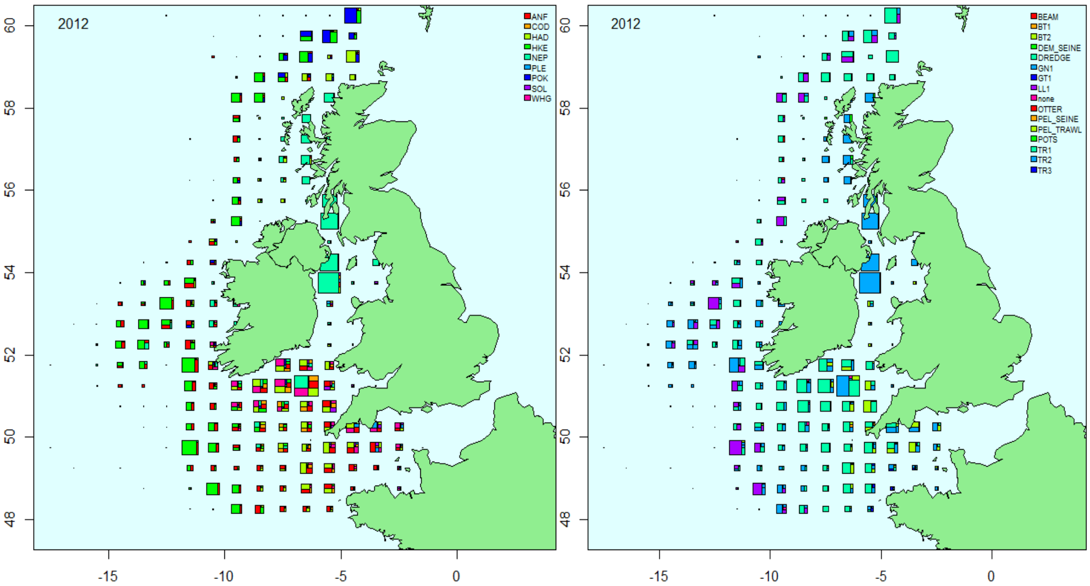

Figure 1 Spatial distribution of the catches of main targets species and catches per gear in the Celtic Sea, based on STECF catch data.

3.1.1 Celtic Sea proper (VIIe-k including Western Channel)

This is the dominant trawl activity in the Celtic Sea OTB and OTT and two major mesh size ranges 100-119 and 70-99mm codend. Within the DCR Level 6 métier OTB&OTT_DEF_70–99 there are two distinct métiers targeting mainly gadoids and benthic species (mainly anglerfish). The former has been declining in importance in recent years whereas the latter has be-come more important. The fleet targeting Nephrops is OTB&OTT_CRU_70–99. Again there are two distinct métiers recognized by WGCSE one focused almost exclusively on large volumes of small Nephrops (i.e. where Nephrops accounts for >60% of the landed weight) and one with more mixed Nephrops and demersal fish catches. The former is focused on the Celtic Sea deep or "Smalls" mainly whereas the latter is more spread out throughout the Celtic Sea where there is suitable habitat for Nephrops.

Beam trawl (TBB_DEF_70–99) targeting flatfish, operated and monitored by respectively UK, Belgium and Ireland. The distribution of the activity covers certain grounds where sole, anglerfish, cuttlefish and megrim are abundant and the seabed is suitable for beam trawling. This DCR level 6 métiers GNS_DEF_120-219_0_0 includes set gillnets mainly targeting anglerfish (Lophius spp.) and those targeting gadoids.

Common cuttlefish (Sepia officinalis) are also exploited in the Celtic Sea, whilst there is dredging for scallops and smaller bivalves in the western English Channel, Irish Sea and west of Scotland. Pot fisheries take place for lobster (Homarus gammarus) and edible crab (Cancer pagurus) in coastal areas of this region

The main gill (GN1) and trammel (GT1) nets effort are from the French and English fisheries. The GN1 effort is widely spread in the Celtic sea, but most the effort is close to the English and French shore (Figure 2.1-6). Both fleets mainly target demersal species including hake and pollack (Pollachius pollachius). The French fleet also targets for crustacean species (Spider crab and common crab). Also a Spanish small fleet (only 2 vessels) target hake operated in Divisions VII j and VIIk. A pilot survey in 2006 showed a discard rate < 5%, so discards sampling programme was not focussed on gillnets. There is an important Irish gillnet fishery targeting cod in VIIe between January and March. Much of this fishery is operated by vessels under 12m. The trammel net effort is less wide spread than the gillnet fishery and most of the effort is carried out close to the Brittany coast. The targets species for this fishery are sole, anglerfish and crustaceans (Spider crab and common crab).

3.1.2 Irish Sea (VIIa)

The main gear in the Irish Sea is demersal trawls. Several sub fleets exist within this fleet. The largest of these are the otter trawls, with a small proportion of demersal seines. The otter trawl vessels of this fleet primarily utilize 80 mm mesh codends. The majority of this fleet belong to targeted Nephrops fisheries. Two main Nephrops fisheries exist in the Irish Sea, one in the East (FU14) and one in the West (FU15). These fisheries are generally seasonal and confined to the summer months although the season has been extending in recent years. A number of other species are caught in relatively low levels by this fishery, including cod, haddock, plaice, anglerfish, and to a lesser extent sole. Although relative landings of cod within this fishery are low compared with the quantities of Nephrops landed, this fleet's contribution to the total cod landed within the Irish Sea is generally high. A small proportion of the demersal trawl fleet utilizes 100–119 mm meshes and targets the traditional whitefish fishery. This takes a mixture of species, specifically cod, haddock and whiting which used to be an important fishery within the Irish Sea, but has declined to low levels since 2003 following the adoption of larger meshed gear.

A beam trawl fleet operates within this area and the majority of vessels employ meshes in the range of 80–89 mm. This fleet primarily targets flatfish species, plaice and sole in particular. There is also a fishery for ray species. These fisheries have bycatches of anglerfish, and low catches of cod, haddock and whiting. Gillnetting also occurs in the Irish Sea. However, this is a very small fleet within the Irish Sea, accounting for around 1% of effort. Effort is focused to the south/southwestern area of the Irish Sea and is a subsection of a larger fleet operating within the Celtic Sea. In addition there is some gillnetting activity around the Isle of Man, however this is minimal. The primary target of those operating in the southern area is cod. Low landings of other species including haddock, saithe and anglerfish also occur. In relation to mesh size, although a number of different ranges are used, 150–219 mm has dominated in the last couple of years, moving away from 100–149 mm which used to be the primary mesh range used.

3.1.3 West of Scotland (ICES Subarea VIa)

The demersal fisheries in Subarea VI are predominantly conducted by otter trawlers fishing for prawns (Nephrops); cod, haddock, hake, saithe, and whiting (gadoids); anglerfish and megrim. Other species including lemon sole, plaice, witch, red mullet, halibut, turbot and pollack form a proportionally small but valuable part of the catch. Trawlers may target a particular species assemblage in particular areas, but invariably catch some mixture of species. Generally one can consider there to be:

An inshore fishery targeting prawns (with smaller catches of gadoids). The fishery mainly uses trawls with a mesh size of 80mm although there is also some creel fishing. There are separate fisheries in the Minch, the Firth of Clyde and the Sound of Jura. These fisheries mostly involve Scottish vessels;

- A shelf fishery for the gadoids. This mainly involves trawls with a mesh size of 120mm. Scottish vessels predominate, with smaller numbers of vessels from Ireland, Northern Ireland, England, France, Spain and Germany;

- A fishery close to the shelf edge targeting anglerfish and megrim. This is mainly a trawl fishery involving Scottish and Irish vessels. In addition, French vessels catching anglerfish may be targeting saithe and other demersal species or fishing in deep water for roundnose grenadier, blue ling or orange roughy. Spanish and UK gillnetters and longliners, work along the shelf edge targeting anglerfish, hake and ling but occasionally moving into deeper water to fish for deep-water sharks;

- A fishery at Rockall targeting haddock on the bank (<200 m) and anglerfish on the slope (>200 m). This is mainly a trawl fishery involving Scottish and Irish vessels, with sporadic involvement of Russian vessels on the southwest part of the bank that falls within international waters.

In addition to these main demersal fisheries, some inshore vessels on the west coast of Scotland turn to scallop dredging when Nephrops catches or prices drop. A seasonal sprat fishery often develops in the south Minch in November and December, which is targeted by vessels of all sizes (including those that usually target Nephrops).

3.2 South Western Waters

3.2.1 Bay of Biscay

Bay of Biscay (Figure 2**Error! Reference source not found.Error! Reference source not found.**) is a highly productive system. It creates the perfect conditions to multispecies fleets to make use of this productivity.

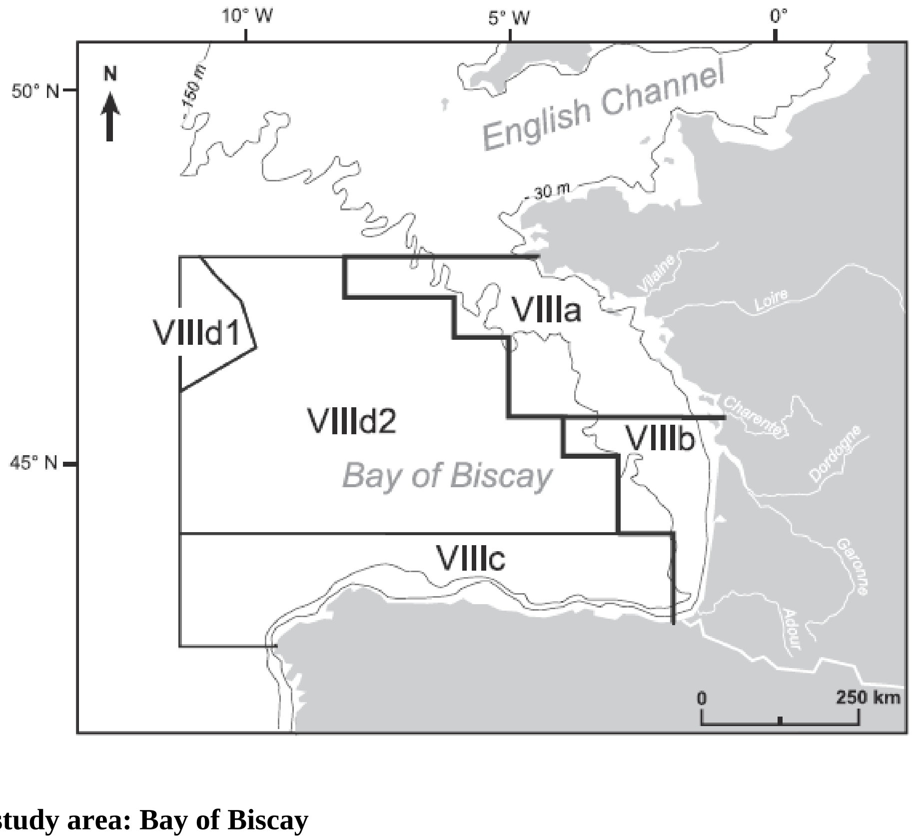

Figure 2. Case study area: Bay of Biscay

More than 200 species are caught in the Bay of Biscay with 20 species contributing to 80% of the landings. Main species in value are sole, Nephrops, hake, monkfish and seabass. Bay of Biscay concentrates important mixed demersal French and Spanish fisheries of trawlers, netters and longliners with a high degree of technical interactions between fleets through species.

The fisheries in the Bay of Biscay are mainly managed through conservation measures imposed by the Spanish and French administrations. Sole, Nephrops, Hake and Monkfish are thus submitted to TAC and quotas system, minimum landing sizes, technical measures (mesh sizes limits and selectivity measures), (EC Reg. No. 850/98 and 1239/98). Effort reallocation for the different fleets may be restricted by constraints in terms of TAC and national quotas consumption.

The demersal Spanish fleets operating in this area are composed of bottom trawlers, longliners and netters. These fleets are managed through TAC and TAE, apart from some other technical and physical measures. These two regulations (TAC and TAE) come from different origins.

The TAC was first implemented when Spain joined the EU in 1986. Setting TACs involves the fixing of maximum quantities of fish that can be caught from a specific stock over a given period of time. This operation requires cooperation among the various parties enabling those involved to come to an agreement regarding TACs and an allocation key for sharing them. The EU went on to share fishing opportunities in the form of quotas among Member States. A formula was devised to divide TACs according to a number of factors, including countries' past catch record. This formula is still used today, on the basis of what is known as the principle of 'relative stability' which ensures Member States a fixed percentage share of fishing opportunities for commercial species. Even if the share has been maintained stable over time, the growing scarcity of the key stocks has eroded significantly the fishing opportunities for these fleets.

The TAE is previous to the TAC regulation. In 1981 it was decided to list all the Spanish vessels operating in Divisions VIIIa,b,d and Sub-areas VI and VII, in order to create the access rights to these fisheries (a single fishing right per vessel). The idea was to maintain fixed these rights even if the number of vessel decreased. When Spain joined the EU the number of vessels in that list was close to 300 and the so-called “300 list” was created. These fishing rights became transferable by area.

Finally, concerning technical measures, some mess size limitations and minimum landing sizes for some stocks have been implemented. Further information on how this fishery is managed can be found in Iriondo et al. (2013), Prellezo et al. (2009) and Prellezo (2010).

In 2013, 792 French vessels operated in the Bay of Biscay demersal fisheries. It represented around 25% of the total French vessels operating in the Atlantic and 49% of the French vessels operating in the Bay of Biscay. The bay of Biscay French demersal fisheries total gross revenue was calculated at around 249 million euros in 2013, and total direct employment amounted to 2256 fishermen.

Most important species caught by French vessels, in value, in the demersal fisheries in the Bay of Biscay are Common sole (17%), Nephrops (10%), European hake (10%), monkfishes (9%), Common cuttlefish (4%) and Sea Bass (4%) (percentages of the total gross revenue for those fleets).

Two main fleets of bottom trawlers and netters operate in these fisheries among which several strategies and specializations are observed. A fleet typology was developed together with stakeholders in the framework of the partnership bio-economic working group (PBEWG) and the European GEPETO project to provide a more detailed approach than DCF segmentation of fleets’ situation, strategies and potential impact of management plans (Figure 1). 21 fleets were considered in the analysis (see table 1). These fleets are subsets of DCF fleet segments. Hereafter, Sole gillnetters, mixed gillnetters, Nephrops trawlers, Mixed demersal and Mixed demersal coastal trawlers, hake longliners and hake gillnetters are considered, each fleet being divided in vessel length (VL) categories. 3 fleets can be considered as small scale fleets (SSF) according to EC definition (Vessels <12m using passive gears exclusively). These SSF represent 38% of the vessels number, most of them being Sole gillnetters.

Main fleet segments in terms of vessels are mixed bottom trawlers (210 vessels) and mixed netters (263 vessels). Nephrops trawlers account for around 150 vessels and sole netters for around 130 vessels. Hake specialized fleets (longliners and gillnetters) only account for around 30 vessels but concentrates a large part of the French landings.

The main fleets in terms of gross revenue are the Nephrops trawlers (specialized) VL1224 (12% of the total gross revenue of French demersal fleets in the Bay of Biscay), the Hake gillnetters VL1840 (12%), the Mixed demersal trawlers North Bay Biscay_VL1824 (10%) and the Sole gillnetters_VL1218 (10%).

The Bay of Biscay demersal fisheries are complex mixed fisheries with high level of technical interactions between fleets through species caught by different fleets and joint productions. Joint productions occur at the trip and métier level for a given season and area. Estimation of production functions and joint production thus requires disaggregated data. At the year level, mixed production of fleets observed can result from practicing different métiers along the year and in different area.

As expected, data highlight that trawlers have more multi-species catches than netters or longliners with as a consequence less ability to reconcile catches.

Landings by fleet show that fleets operating on sole also catch hake but in different proportions according to fleets: For Sole gillnetters VL1824, hake represents 11% of their total landings (17% of their total value) while it represents 1% (4%) and 4% (5% in value) for Sole gillnetters VL1012 and VL1218 respectively. For Nephrops trawlers (specialized) VL1224, Nephrops is the first species (55% in value) but Hake or Sole appears to be significant level in the landings

For specialized fleets on hake (hake longliners and gillnetters), sole catches are not observed. Those fleets don't operate on the distribution area for sole which is more coastal.

Analyses of landings by fleet-métier enable to precise correlations between species and show in particular that sole landings by netters are due to trammelnet métier for sole while catches of hake by the same fleets are due to gillnet métier. There is thus ability for these fleets to reconcile both objectives while hake and sole (and other species) are caught by same bottom trawlers métiers. Proportion of species varies however according to main strategies of bottom trawling (demersal trawl cephalopods, Nephrops, sole or anglerfish) which also correspond to different spatio-temporal allocation of the effort.

3.2.2 Iberian waters

The Atlantic Iberian waters (ICES Divisions VIIIc and IXa) include three areas with different oceanographic characteristics: Gulf of Cadiz with Mediterranean influence, Atlantic front under a strong upwelling process, and Cantabrian Sea (southern area of Bay of Biscay). They include the transition between subtropical and sub-polar areas. Politically, the Atlantic Iberian waters are divided into the Spanish and Portuguese national waters. The current analysis of the Iberian waters only considers the Atlantic front and the Cantabrian Sea.

Vessels that operate in Atlantic Iberian waters belong to the national fleets of Spain and Portugal. Therefore, the vessels fishing Iberian stocks (ICES VIIIc and IXa) have to apply for a fishing licence to operate in the respective National waters. Both countries classify their national vessels in fleet categories depending of the gear type (trawl, purse seine, gillnet or longline), and both countries leave an independent group for the small-scale fleet.

These fleets operate on a narrow continental shelf where they exploit a variety of fishing resources by using different type of gears (trawl, gillnet, long lines…), forming a common demersal mixed-fisheries fleet. Although recent changes in fishing strategies and gears design have led some traditional demersal fleets to also exploit pelagic species, is not simple the combined management of demersal and pelagic stocks. On the one hand, most of the landings of pelagic stocks are made by fleets (purse seine, hand lines…) without any effect on demersal stocks. On the other hand, the populations of large pelagic species usually inhabit wide oceanic areas, so their life cycle is developed beyond the geographical limits of the case study.

4 METHODS AND DATA

4.1 Addressing the ToRs

In order to address the questions asked by the request to STECF, the work was organized around three issues/subjects/questions:

- Which are the potential changes in the EU fisheries under the different scenarios set by the request (items 3.1-3.3 of the request).

- Which are the advantages and consequences of different configurations of the MAPs with relation to their spatial scope (item 3.4 of the request).

- Will management applied to the driver species be able to constraint the catches of the non-driver species (item 3.5 of the request). The second part of this item was lifted from the EWG1502 report (STECF, 2015).

Although the ToRs provided a list of species and fisheries, the time available to include them in FLBEIA and IAM was too short. It’s important to note that adding species and fisheries to a simulation algorithm is not a trivial process, which may require several months of work.

4.1.1 Evaluating scenarios using quantitative methods

Following the best practices in the field of scientific policy advice, the evaluation of the regulation proposal was carried out using simulation testing. For the purpose of this report recent developments in the modelling tools for fisheries management were used, produced under the European projects GEPETO, SOCIOEC, MYFISH and DAMARA; as well as the national projects Bio-economic partnership working group project funded by the French Directorate of Sea Fisheries and Aquaculture since 2009, ANR ADHOC project (2010-2014) funded by the French National Research Agency, SIMLO (FEP 04-2014-00650) and projects funded by the Directorate of Fisheries and Aquaculture of the Basque Government.

The ToRs set a number of questions that were not possible to approach using a single comprehensive model. The settings are complex and the forecasts require strong assumptions to be made, in particular the effect that the Landings Obligation (LO) will have on the fleets behaviour is very uncertain. On the other hand the removal of HCRs from the MAP legislation, introduced an extra level of complexity to be simulated, which was new for the current model frameworks and techniques.

The new framework for MAPs requires a shift in the analysis concepts, from a situation where scientists were required to assist policy makers designing a MAP by studying the trade-offs of candidate HCRs, to a situation where scientists are required to evaluate the added value of implementing a MAP when compared with a baseline. To deal with this new framework a new approach had to be developed in a very short time frame.

The EWG used several models available and defined the scenarios in forms that were expected to provide the necessary information to support the advice. The time frame available was very limited, which conditioned the possibility to test different options to implement the scenarios in each model.

To depict the trade-offs between the MAP and the baseline scenario, the results were presented in relative terms to the baseline. As such the figures present a direct comparison between management options.

4.1.2 Employment and fleet dependency

For the purpose of estimating how employment may be impacted by a change in FMSY, an analysis was undertaken to highlight fleets with "high" and "low" employment. Employment numbers were then combined with the economic dependency of each fleet segment (landings values of the selected species compared to the total landings values in FAO Area 27) to identify fleets that are likely to be impacted by the MAP while being at the same time large employers.

The data submitted by the MS for the Annual Economic Report (STECF, 2013) for the year 2012 was used. The aggregation used for the social and economic data does not allow the analysis to be performed separately by sub-region, neither at the detailed level of fishing activities or métiers used in the MAP simulations. For instances, the DTS group includes several types of trawlers (e.g. demersal trawlers, pair trawlers, beam trawlers), different mesh sizes and target species. These aggregations limited the conclusions that can be drawn concerning the fleets dependency on the MAP driver species.

The first step involved taking relevant data from the AER database, for the fleets operating in the Celtic Sea, Bay of Biscay and Iberian Waters, including: employment (total number employed), landings value for the MAP main species (hake, Norway lobster, sole, megrims, anglerfishes and pollack) and the total landings value at the FAO Area 27 (Northeast Atlantic). The economical dependency on the fishing activity in the WW on those target species was calculated. The final evaluation included the total employment for fleets operating in the area, focusing on the value of landings from these species compared with each fleet overall total landing values, in order to estimate fleet dependency on these stocks.

4.1.3 Number and scope of MAPs

To address this question, the EWG discussed which may be the main elements of a MAP. Based on the discussion the EWG elaborated on the pros and cons of each option. This ToR was addressed through qualitative expert knowledge. There was no quantitative support to this ToR.

4.1.4 Management of by-catch (fishery approach)

To explore the potential impact of management measures applied to the "target" species into the "by-catch" species, the EWG used, as in EWG 15-04 report. The rationale is that if caught together, a management reducing or increasing the TAC (effort) on one of the main species might impact the other species which part of the catch assemblage.

4.2 Provisional Fmsy ranges

One of the most important elements of the new MAPs is the list of Fmsy ranges for each stock considered by the MAP. In the case of the European Western Waters these values should have been provided by ICES. However, for the stocks in this area the ICES advice is scheduled for late 2015. As such, to carry on with the evaluation of the MAP proposals, the EWG computed provisional Fmsy ranges which try to keep the fundamental concepts required by DGMARE, the fishing mortality ranges that produce 95% of the estimated catch when the stock is fished at MSY levels. Annex VI presents three working documents detailing the methodologies used. The values are presented in Table 3.

Table 3. Values of Fmsy, and their lower and upper range, as used in the analyses.

Stock	Fmsy	Lower limit	Upper limit	Method
Hake (south)	0.24	0.17	0.36	YPR (WD: Abad et.al)
Hake (north)	0.27	0.18	0.37	PLM (WD: Jardim)
Horse mackerel (south)	0.11	0.08	0.16	PLM (WD: Jardim)
Megrim (south)	0.17	0.08	0.19	YPR (WD: Abad et.al)

Sole (Bay of Biscay)	0.26	0.17	0.36	PLM (WD: Jardim)
Blue whiting	0.30	0.20	0.41	PLM (WD: Jardim)
Four spot megrim (south)	0.17	0.11	0.24	PLM (WD: Jardim)
Horse mackerel (western)	0.13	0.09	0.18	PLM (WD: Jardim)
White anglerfish (south)	0.19	0.13	0.26	PLM (WD: Jardim)
Haddock (VIIb-k)	0.40	0.26	0.60	EqSim (WD: Gerritsen and Lordan)
Cod (VIIe-k)	0.40	0.27	0.55	EqSim
Whiting (VIIe-k)	0.32	0.21	0.44	PLM (WD: Jardim)
Sole (VIIfg)	0.31	0.21	0.43	PLM (WD: Jardim)
Plaice (VIIfg)	0.3	0,21	0.43	PLM (WD: Jardim)

The current Fmsy value (0.26) set for the Bay of Biscay sole is based on Fmax, as estimated during WGHMM 2010 (ICES, 2010). The technical basis for this choice relies mainly on the fact that there is no clear stock-recruitment relationship for this stock. ICES notes that this value is ill defined (ICES Advice 2014, book 7) as the current Fmax (0.46 as estimated in 2014) is higher than the one that was calculated using the 2010 data. ICES considers that the basis for FMSY may need to be re-evaluated. Several attempts at estimating it have been made by the ICES WGBIE working group in 2014 and 2015 without success. ICES will again consider this issue during a workshop on Fmsy ranges for western waters stocks scheduled for the fall of 2015.

4.3 Multi-model approach

The scope of the MAPs was too wide to be addressed by any of the models currently available, which included all demersal fisheries and stocks in the South Western Waters (Bay of Biscay and Iberian waters) and the North Western Waters (West of Scotland, Celtic Sea, Irish Sea and Western Channel). As such existing models were further developed and calibrated to specific fisheries to analyse impacts of management measures at the regional level (Iberian waters, Celtic Sea and Bay of Biscay). The approach taken by the EWGs was to invite the scientists involved in modeling these areas to contribute to the evaluation. As a result three models were available; FLBEIA, IAM and a State-Space model.

These are all bio-economic models, although they're based in different modelling concepts. FLBEIA is based on an MSE algorithm with yearly time steps, where the allocation of effort across fishing strategies (metiers) is based on historical effort allocation or on the attempt to maximize profit. Furthermore, total effort is restricted by the TAC advices. Production functions are based on cobb-Douglas for stocks explicitly modelled or on linear relationship with effort for other species. IAM uses stochastic forecast with quarterly or yearly time steps for biological dynamics and yearly time steps for fleets' behaviours. Production functions are based either on Baranov equations for stocks explicitly modelled or on linear relationship with effort for other species. The IAM adjusts and reconciles effort by fleet and metier to meet F or TAC objectives. Allocation of effort across fishing strategies (metiers) was assumed to be based on historical allocation resulting from fishermen behaviours. Both, IAM and FLBEIA are multi-species, multi-fleets and multi-metiers models. The state-space model is a bio-economic multi species equilibrium model.

For the NWW area the EWG used an FLBEIA application to the Celtic Sea. For the SWW area there were an IAM application for the Bay of Biscay, focus on the French fleets operating in the area, an FLBEIA application to the Bay of Biscay, focus on the Spanish fleets operating in the area, and an

FLBEIA application to Iberian Waters covering all the relevant fleets. A summary of the scope and main concepts of these models is presented in Table 4.

Annexes I-V contain detailed descriptions of each of the models, their use in the analyses and additional results that were considered interesting.

4.4 Scenarios

Two sets of scenarios were investigated: the management scenarios and the fleet scenarios. The first relates to decision making options that were simulated to evaluate the trade-offs across options and inform decision makers of the effects/impacts that their decisions may have. The fleet scenarios aimed to inform on the likely responses from the fleets to the decisions taken. Such scenarios are the most difficult to forecast, as the reactions of the sector can vary widely and unexpectedly. Hence, the fleet scenarios are inevitably based on strong assumptions about likely responses, which may or may not be entirely accurate.

4.4.1 Management scenarios

The management scenarios were designed to evaluate whether a MAP with the characteristics proposed by DGMARE (see background), would be more successful at achieving the objectives set by Artº 2 of the CFP, than implementing the basic CFP provisions (baseline scenario).

The basic CFP provisions were interpreted has a situation where the current MAPs would continue to be applied and the CFP provisions added on top of those. The CFP provisions in this context are the LO flexibilities and the technical measures.

Technical measures were not possible to simulate. These measures will have to be implemented through co-decision with regional bodies and currently it's unknown which and to what extent these will be implemented. Time constraints didn't allow the EWG to explore through simulation this aspect. It would require a large number of scenarios to be run, in particular in the absence of guidance about which measures are likely to be implemented.

With regards to the LO, the interpretation was that inter-species and inter-annual flexibilities should be part of the baseline, while the *de minimis* and survivability exemptions should be part of the MAPs. However, due to time constraints, these rules were not implemented. There was a significant effort allocated to code these effects, nevertheless the results obtained were not satisfactory and were not included in the report. The LO is introduced in 2018 through the limitation of discards, and the uplift of the TAC to cover the total removals and not just landings.

The new MAP framework does not include HCRs, meaning that the Council has the freedom to decide on how it wishes to fix fishing opportunities and achieve the objectives of the CFP. The EWG was therefore faced with the problem of how to evaluate the provisions of the MAP in the absence of an HCR to derive a target fishing mortality rate. The EWG decided that the best alternative would be to use an "envelope" approach. Such approach considered the potential consequences of fishing at the limits (upper and lower) of the F_{MSY} ranges, to simulate both high and low exploitation cases, and thereby inform managers on the range of potential outcomes of alternative tactical management decisions, without giving advice about the 'best' way to get to the target.

Note that in this approach each scenario has two management options that lead to two simulations:

- upp – TAC_{Y+1} is set as the catch that results from exploiting the stock at $FMSY^{upp}$

- low - TAC_{Y+1} is set as the catch that results from exploiting the stock at $FMSY^{low}$

Table 4. Overview of the models used for the WW management plans evaluation

Western Waters models for ex-ante evaluation	FLBEIA IW	FLBEIA BoB	IAM	FLBEIA CS
Fishery description				
Multispecies (M) / Single species (S)	M	M	M	M
Seasonal				
Vessels LoA group				
< 12 m (small scale fishery)			X	x
12-24 m			X	x
24-40			X	x
>40 (long distance fishery)				x
Type of gear used				
passive	X	X	X	x
active	X	X	X	x
polyvavent	X		X	
Fleets disagreggation Level				
Economic fleet segments			X	
Metier 4 (gear type)	X	X	X	x
Model characteristics				
Optimisation			X	
Simulation	X	X	X	x
MSE	X	X	X	x
MSE - full feedback loop with stock assessment model	At present just time lag but it would be possible			At present just time lag but it would be
MSE - implementation error	Derived from mixed fisheries dynamics			Derived from mixed fisheries
Time step	Annual	Annual	Year (quarterly SS3 dynamics)	Annual
Spatial (Y/N) in case of Y resolution (…)				N
Spatial coverage (North Sea, Skagerrak (Sk), Eastern Channel (EC))	Iberian Waters	BoB	BoB	Celtic Sea (VIIbc,e-k)
Population dynamics				
Biological structure				
age (A)	X	X	X	X
size (S)				
biomass (B)	X	X	X	X
Processes: dynamic recruitment (Drec), growth (Gr), Migration (Mig)	Drec	Drec	Drec	Drec
Simulate recruitment failure (Y/N)	X	X	X	X
Fleet dynamics				
based on F (F) / effort (E)	E	E	E	E
selectivity (model or fixed)	In the present conditioning it is fixed but it can be modeled		m/f	fixed
Economic dynamics				
Price elasticity	In the present conditioning it is fixed but it can be modeled		potentially	conditioning it is fixed but it can
Costs	In the present conditioning it is fixed but it can be modeled		X	In the present conditioning it is
Employment or FTE	Variable, function of number of vessels		X	Variable, function of
Fuel costs	In the present conditioning it is fixed but it can be modeled		X	conditioning it is fixed but it can
MANAGEMENT OPTIONS (Yes/No/Development)				
De minimis	Available but not used		X	
Interspecies quota flexibility	Available but not used			
Swaps	Available but not used			
Borrow and banking	Available but not used			
ICES data limited stocks	HCR for DLS			X
F target	X	X	X	X
TAC & quotas	X	X	X	X
Biomass safeguards	X	X	X	X
Combined TACs (multiple species in one TAC)				
Diferenciated management between driver and non-driver stocks				
Multidimentional Fmsy ranges				
Harvest control rules	X	X	X	X
Temporary closure of fishery				
Area closures				?
INDICATORS (Yes/No/Development)				
Impact on biodiversity				
Abundance of main stocks	X	X	X	X
Evolution of main predator and prey stock				
Profitability	X	X	X	X
Income	X	X	X	X
Supply	X	X	X	X
Fuel consumption			X	
Employment	X	X	X	X
Compliance				
Stocks				
	Hake (south)	Hake (north)	Hake (north)	Cod VIIbc,e-k
	Horse Mackerel (South)	Megrim	Sole	Haddock VIIb-k
	Megrim	Blue whiting	Nephrops	whiting VIIbc,e-k
	4 Spot Megrim	H.Mackerel West	Monkfish	ole VIIfg
	Monkfish	Mackerel	Megrim	plaice VIIfg
	Blue whiting		Sea bass	Nephrops FU22
	Horse Mackerel (Western)		Pilchard	Anglerfish7&8
	Mackerel		Anchovy	
	Others		Mackerel	
			Horse mackerel	
			Pollack	
			whiting	
			Blue whiting	
			Rays	
			Cephalopods	
			Red mullet	

where $FMSY^{upp}$ and $FMSY^{low}$ are the upper and lower limits of the FMSY range, respectively.

In both cases the biomass safeguards were set at the precautionary biomass (Bpa). In the absence of an HCR to define the tactics to recover the stock, recovery was simulated as a linear increase in SSB up to the safeguard. There were two recovery periods simulated, 5 and 10 years, as requested by the ToR.

4.4.2 Fleet scenarios

The likely responses of the fishing sector to any management decisions are of major importance when forecasting potential stock and fleet impacts. The range of potential responses is very wide, which makes it extremely difficult to forecast. Although a large effort was allocated to modelling fleet response to management, the results obtained were not satisfactory. In most cases there were large differences with what was observed in the past, and the EWGs were not able to find justifications for such differences. Consequently, only one fleet behaviour was simulated, in which the fleets distribute their fishing effort in the same way they've done in the past, reflecting a strong inertia to change in face of the new management options.

4.4.3 Scenario summary

In summary, 1 fleet scenario and 3 management scenarios were investigated. Implementation of the provisions of the MAP comprised 2 options to perform the envelope analysis. Table 5 summarizes each scenario and how they were used to address the different ToRs.

Table 5. Summary of scenarios analysed.

Management scenario				**Fleet scenario**
Name	**Runs**	**Description**		**Historical inertia**
Baseline	cfp	Target:	Fmsy	ToR 3.1-3.3)
		Time to target:	2016	
		Landings obligations:	2018	
MAP fast recovery	map.low	Target:	lower limit of Fmsy range	
		Time to target:	2016	
		Landings obligations:	2018	
		Safeguards:	Bpa	
		Recovery period:	5 years	
	map.upp	Target:	upper limit of Fmsy range	
		Time to target:	2016	
		Landings obligations:	2018	
		Safeguards:	Bpa	
		Recovery period:	5 years	
MAP slow recovery	map10y.low	Target:	lower limit of Fmsy range	
		Time to target:	2016	
		Landings obligations:	2018	
		Safeguards:	Bpa	
		Recovery period:	10 years	
	map10y.upp	Target:	upper limit of Fmsy range	
		Time to target:	2016	

		Landings obligations:	2018	
		Safeguards:	Bpa	
		Recovery period:	10 years	

4.5 Data

A summary of the data and parameters used to tune and condition the models is presented in Table 6. For more details check the model annexes (Annexes I-V).

Table 6. Summary of data and parameters used.

	FLBEIA IB	**FLBEIA BoB**	**FLBEIA CS**	**IAM**	State-space
Population dynamics	ICES 2013	ICES 2014	ICES 2012 or ICES 2014 (where available, truncated to 2012)	ICES 2014	ICES 2013
Fleet exploitation	GEPETO project	ICES 2014	STECF 2013	Ifremer/Fisheries Information System/DPMA 2013	ICES 2013
Fleet economics	STECF AER 2013	STECF AER 2014 Prices from AZTI DB	STECF AER 2013	DCF – DPMA 2013	STECF AER 2013
Fleet interactions	GEPETO	DCF – IEO 2013	STECF FDI (2013)		ICES 2013
Fmsy	ICES 2014 or estimated in meeting				
Bpa	ICES 2014	ICES 2014	ICES 2014	ICES 2014	
Employment	STECF AER 2014				

Processing of model outputs for final analysis and visualization was conducted using the FLR packages (Kell et al, 2007; http://flr-project.org) for the R language (R Core Team, 2015) version 3.1. These toolset is also employed by the software implementing the FLBEIA method.

5 ToR 3.1-3.3 - Evolution of EU fisheries under different scenarios

To compute the effects of the MAPs proposal, a set of simulations were run, implementing the options described by the ToRs. The results were reported for the years 2017, 2021, and 2025, as required.

Note that the results for the 10 years recovery period are not presented. During the exploratory tests no contrast between the 10 and 5 years were found, as such the EWG decided to drop the 10 year recovery scenario due to time limitations.

The results were presented as ratios between the MAP proposal scenarios and the baseline scenario, as such focusing on the differences between the two options, fishing under the CFP provisions or under a MAP framework, which is the simplest way of showing the effect of the MAP. Note that a value of 1 means that there aren't differences between the MAP scenario and the baseline, a value <1 means that there was a reduction of the variable when compared with the baseline, e.g. a value of 0.5 in F would mean that F in the MAP scenario was half of the baseline F, and vice-versa for values >1.

This section is split into North Western Waters, further broke down in Celtic Sea (CS), and South Western Waters, further broke down into Bay of Biscay (BoB) and Iberian Waters (IW).

5.1 North Western Waters

5.1.1 State of the fisheries in 2017

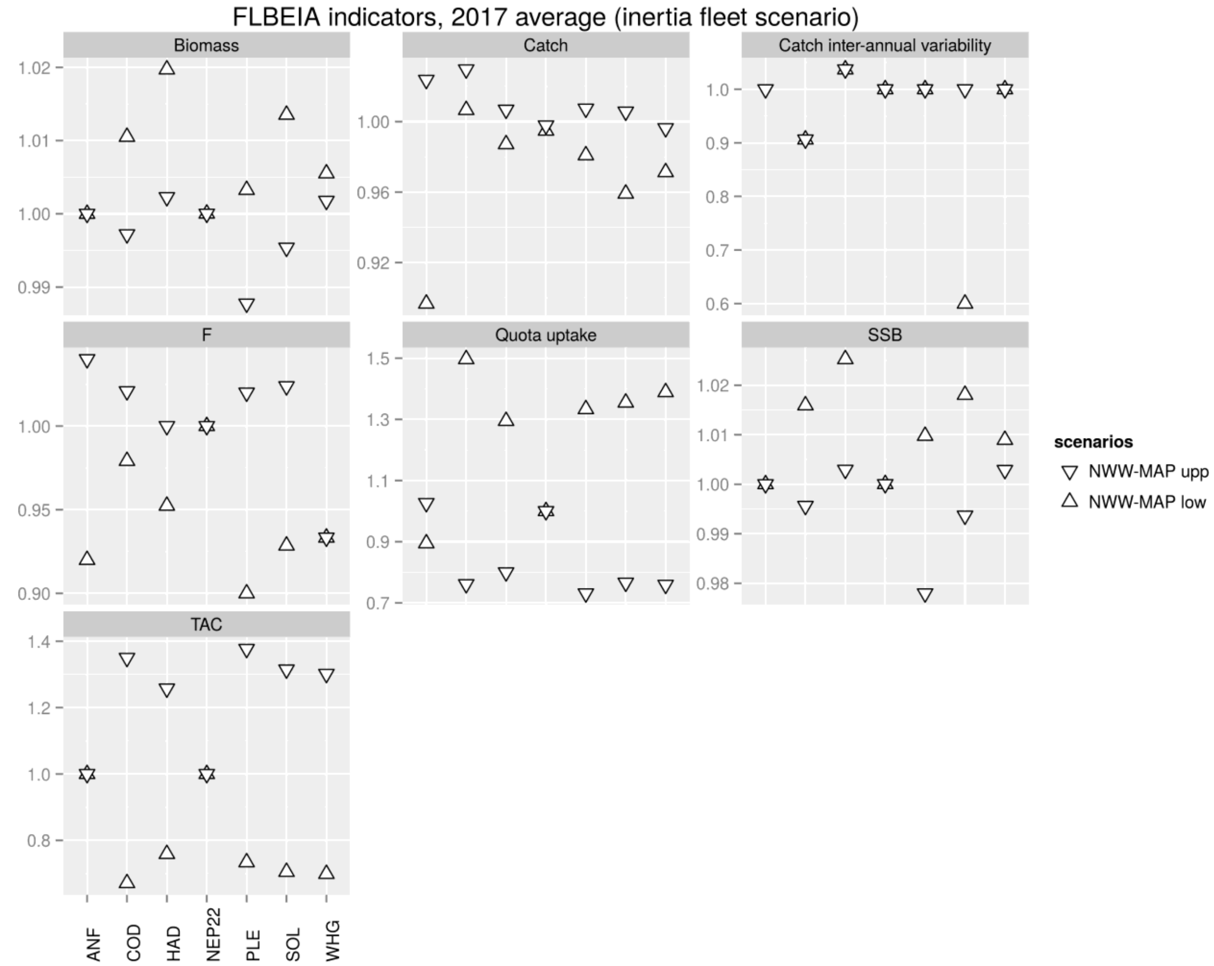

Figure 3. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the NWW MAP in 2017, and for seven stocks in the area.

In 2017 the differences between scenarios are small, with the exception of TAC and quota uptake. TACs are expected to be lower in the case of MAP-low. Monkfish and Nephrops have fixed dynamics. Quota uptake in the MAP-low is higher than the baseline. Note that catches don't change much across scenarios, reflecting the inertia in effort allocations.

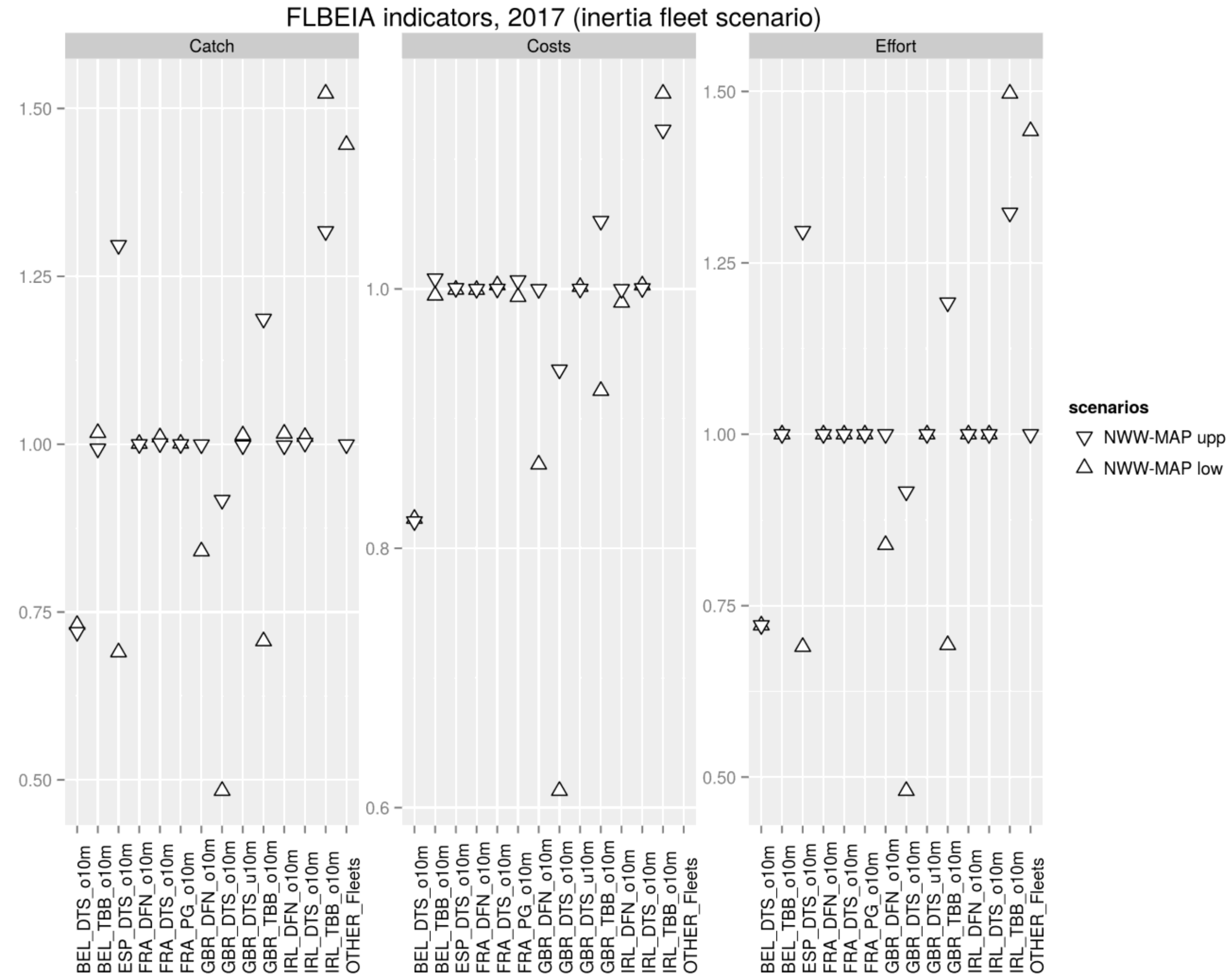

Figure 4. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the NWW MAP in 2017, and for 14 fleets operating in the area.

From a fleet perspective the results show a variety of effect among fleets. Most of the fleets are not sensitive to the MAP scenarios. The Spanish and UK fleets of demersal trawlers and seiners over 10m, and the UK and Irish fleets of TBB over 10m, show larger catches and effort in the MAP-upp scenario in relation to the baseline.The opposite trend occurs in the case of the MAP-low scenario.

5.1.2 *State of the fisheries in 2021*

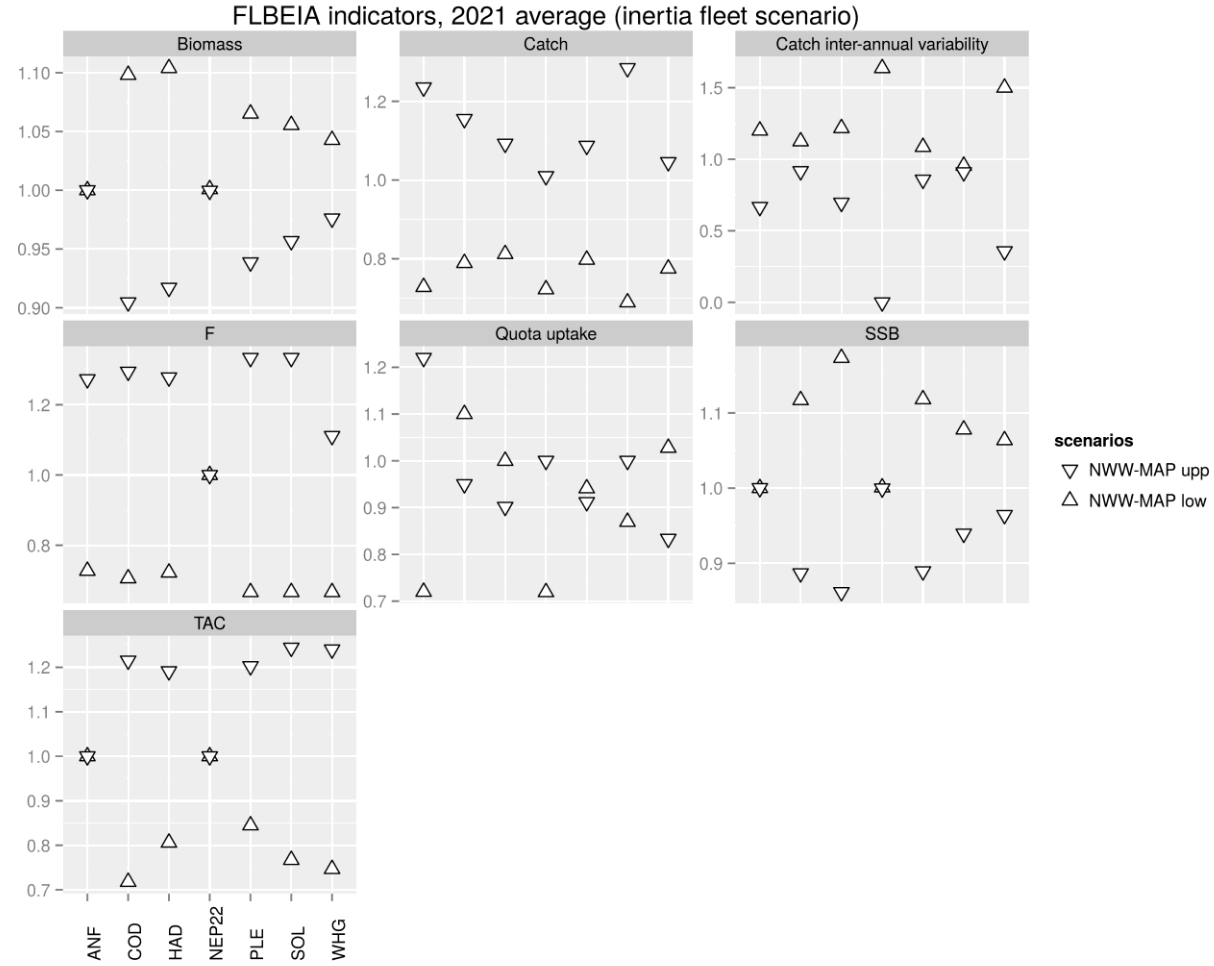

Figure 5. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the NWW MAP in 2021, and for seven stocks in the area.

The outlook for 2021 under the tested condition shows how the different species incorporating in the model are more or less sensitive to the targeted FMSY value. Gadoids show high differences in terms of biomass, SSB than flatfish. However, catches of sole can vary quite extensively.

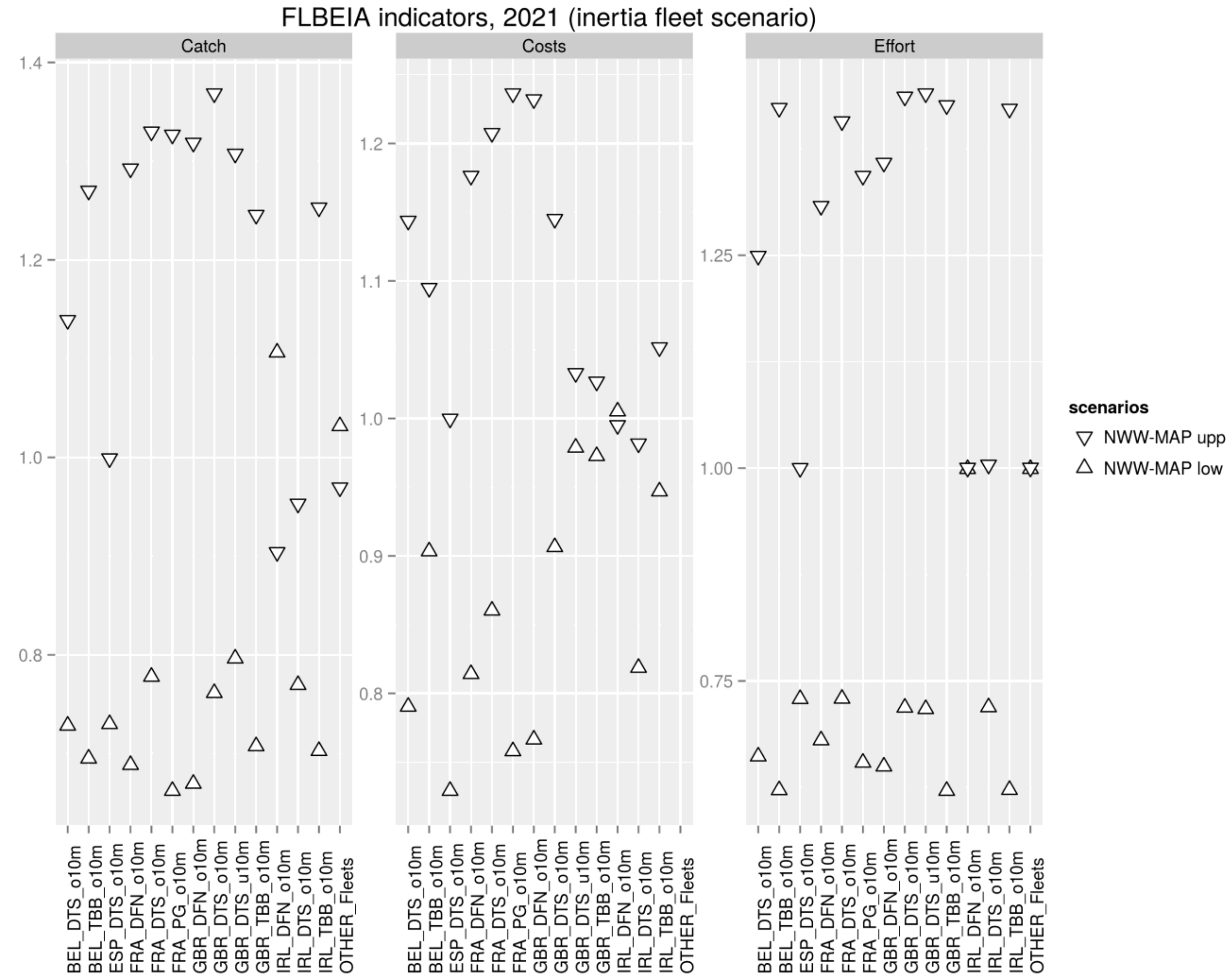

Figure 6. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the NWW MAP in 2021, and for fourteen fleets operating in the area.

In 2021, fishing at the upper limit of the Fmsy ranges will poroduce larger catches for most fleets, ~30%. The Spanish and Irish fleets of demersal trawls and seines over 10m don't show the same increase in catches.

5.1.3 State of the fisheries in 2025

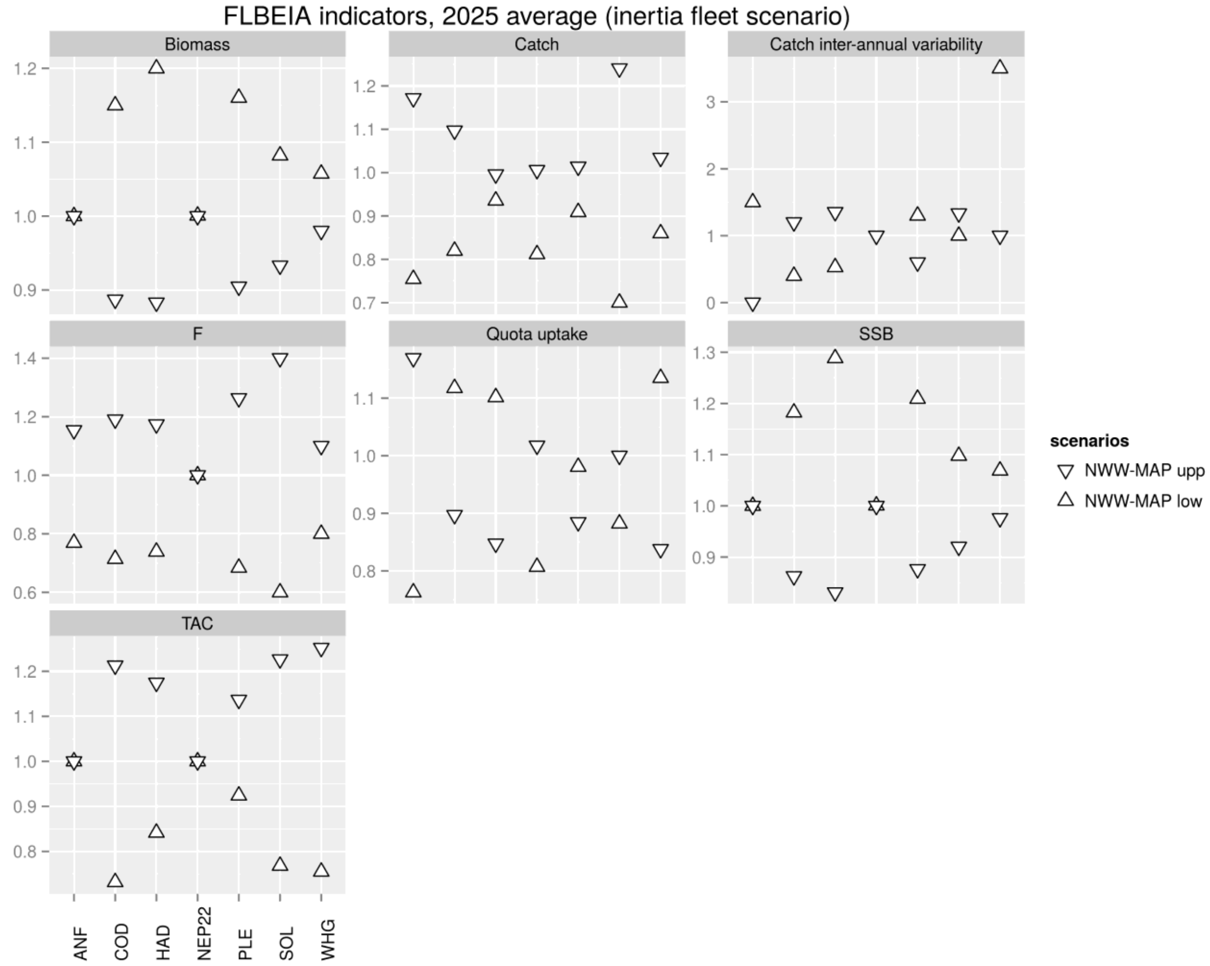

Figure 7. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the NWW MAP in 2025, and for seven stocks in the area.

Catch inter annual variability are more stable than in the previous periods as well as catches of whiting and plaice. Catches of sole are still quite distinct depending on the scenarios. The mixed fisheries interaction are well illustrated by the lack of consistency between, TACs and caches over the studied period.

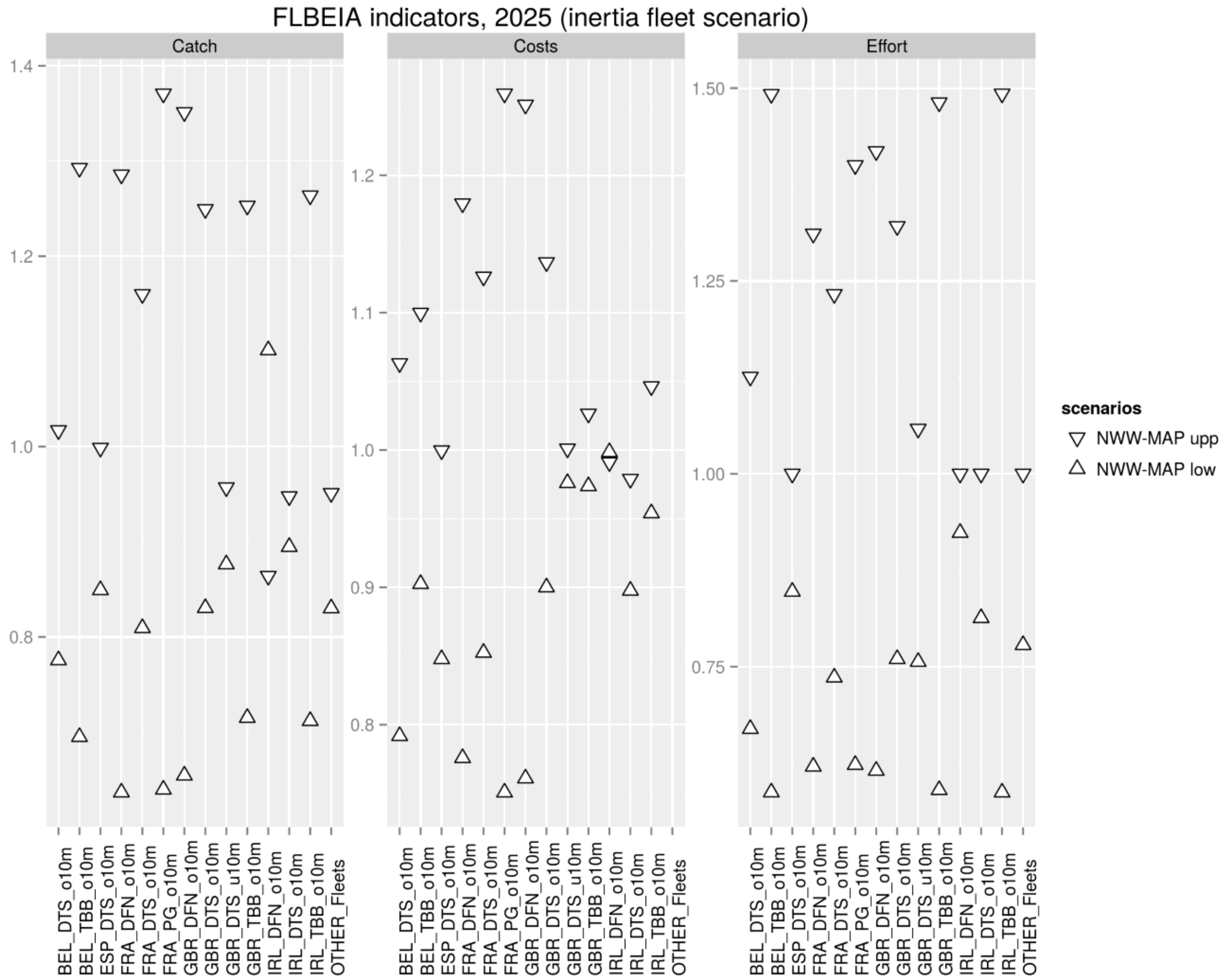

Figure 8. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the NWW MAP in 2025, and for 14 fleets operating in the area.

Some fleets are still not sensitive to the different MAP scenario. As before demersal trawlers and seiners over 10m from Spain, Ireland and the UK don't increase their catches when fishing at the upper limits of the Fmsy range.

Catches by fleet in the scenario MAP-upp seem to increase less in relative terms than effort, which may be reflected in larger costs by catch per unit of effort.

5.2 South Western Waters - Bay of Biscay

5.2.1 State of the fisheries in 2017

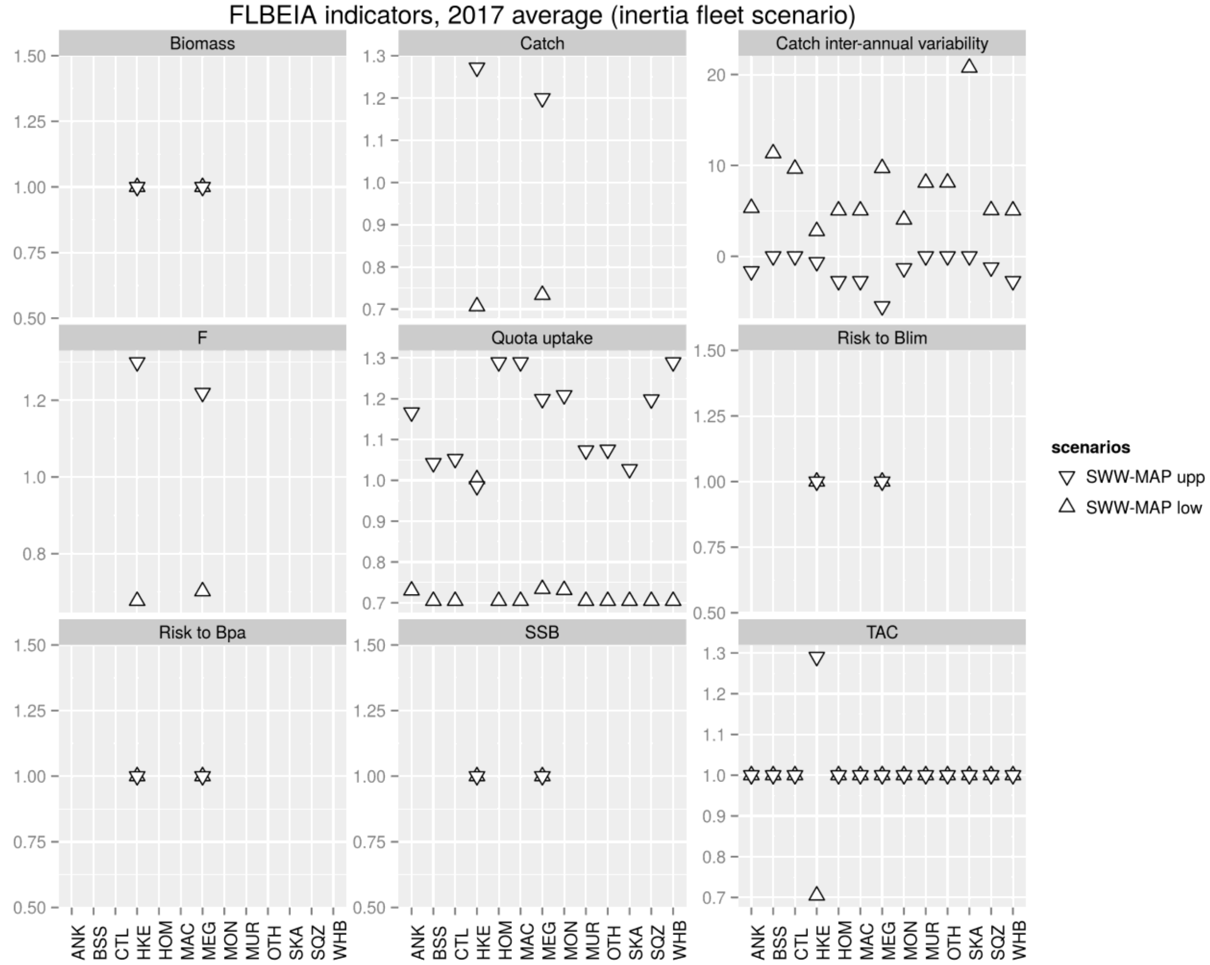

Figure 9. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Bay of Biscay, FLBEIA) in 2017, and for 13 stocks in the area.

The outlook for 2017 under the conditions described above shows that in relation to the baseline the biomass, ssb and biological risks are the same. The TACs, fishing mortality and catch are expected to be higher in the MAP-upp scenario and lower in the MAP-low scenario. As a consequence quota uptake is higher for the MAP-upp scenario and inter-annual variability of catches lower. This scenario affects the short term effects of decreasing fishing mortality to reach the target fishing mortality.

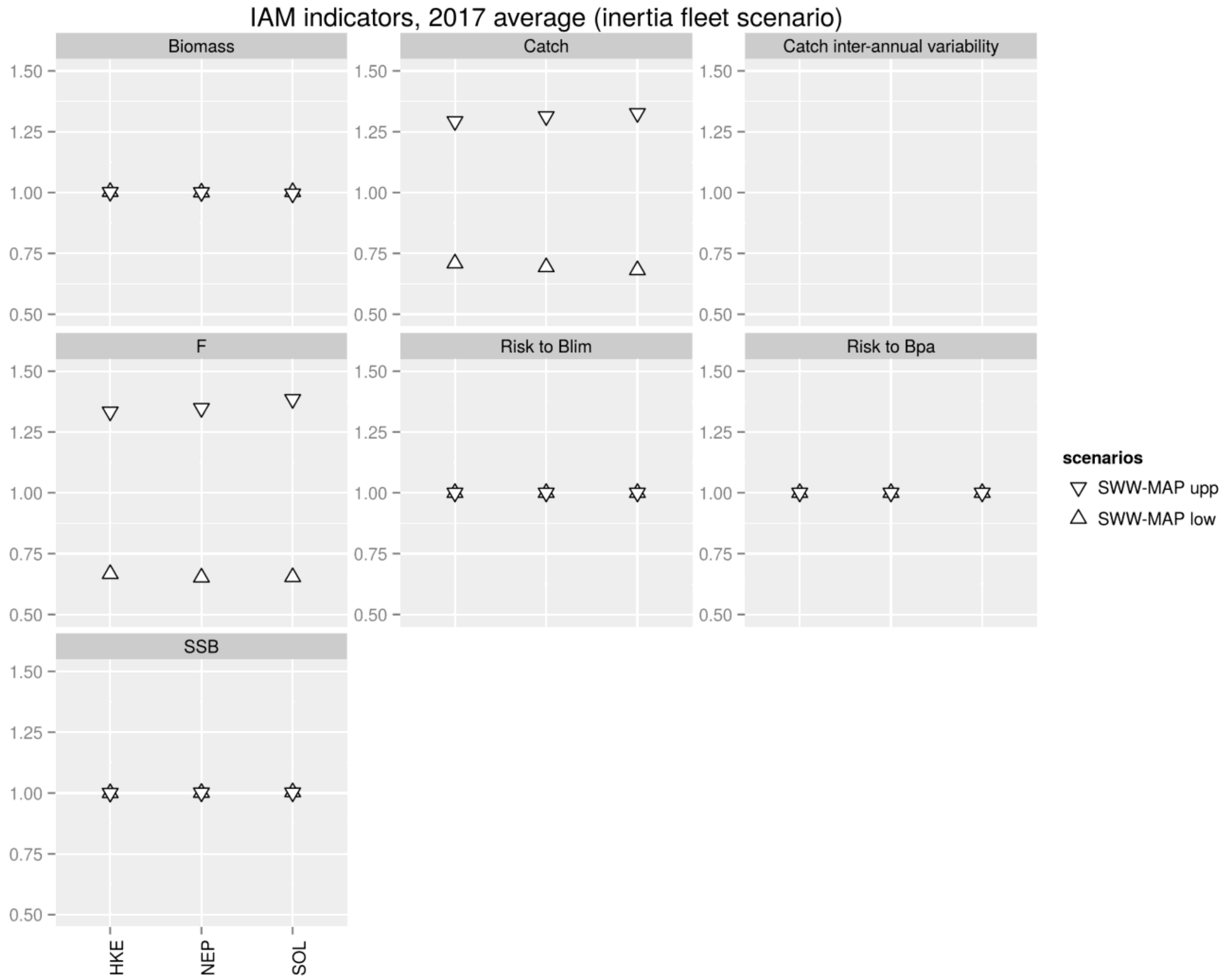

Figure 10. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Bay of Biscay, IAM) in 2017, and for three stocks in the area.

The results obtained by the IAM model are consistent with FLBEIA, showing a similar pattern. Risk to Bpa and Blim and SSB and biomass are the same (or very close) in each of the scenarios for nephrops hake and sole. Fishing mortality and thus catches of hake, nephrops and sole are expected to be higher in the scenario upp than in the scenario low.

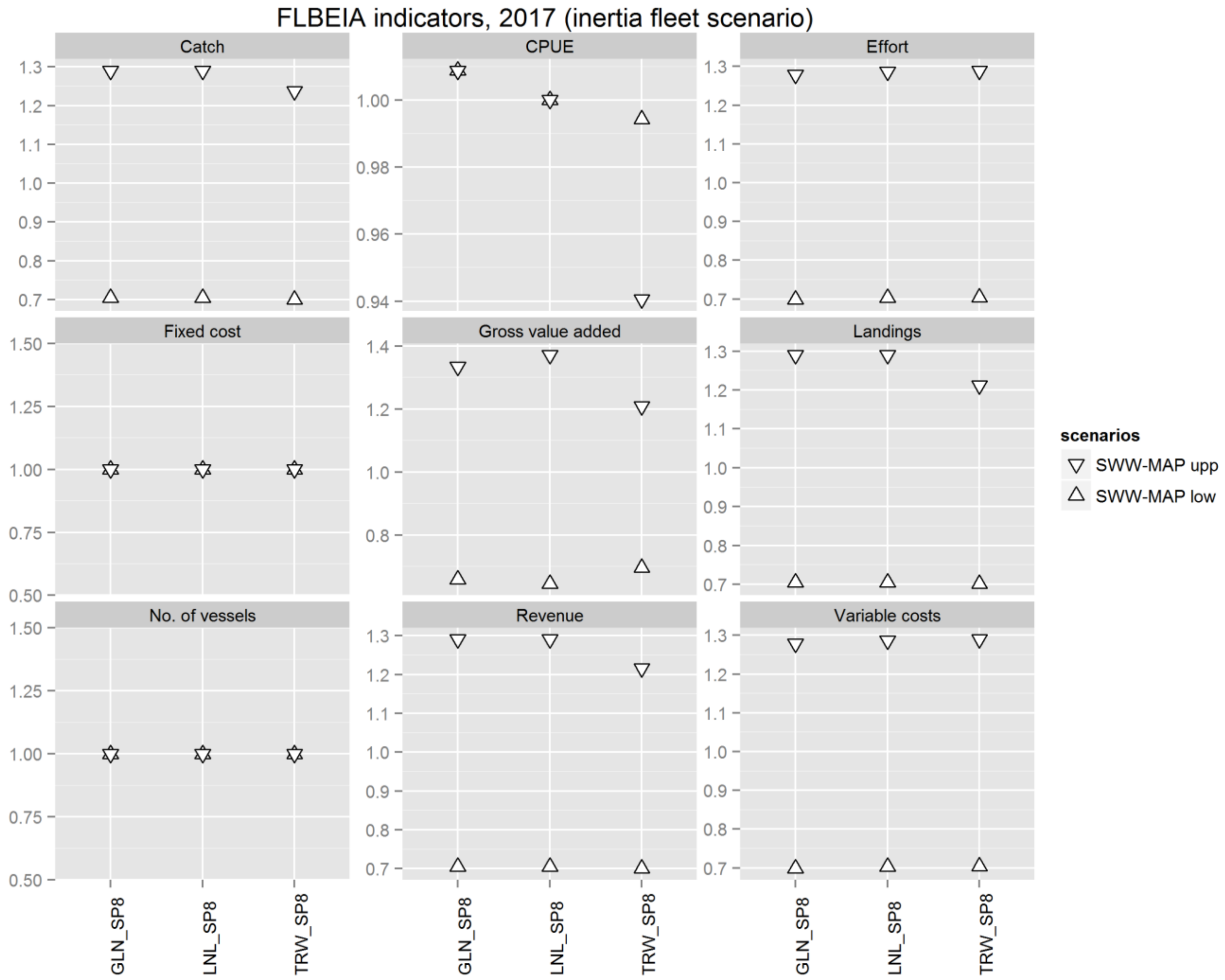

Figure 11. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Bay of Biscay, FLBEIA) in 2017, and for three Spanish fleets operating in the area.

From a fleet perspective the results show similar effects for all fleets, with larger catches for the scenario MAP-upp (~30%), requiring larger effort to be deployed (~30%) with relation to the baseline. The MAP-low scenario shows ~ 30% less for both indicators. Fixed costs are the same, once that the number of fleets in the fishery doesn't change. The economic indicators are all very similar reflecting mainly a scaling of catches (revenue) and effort (variable costs).

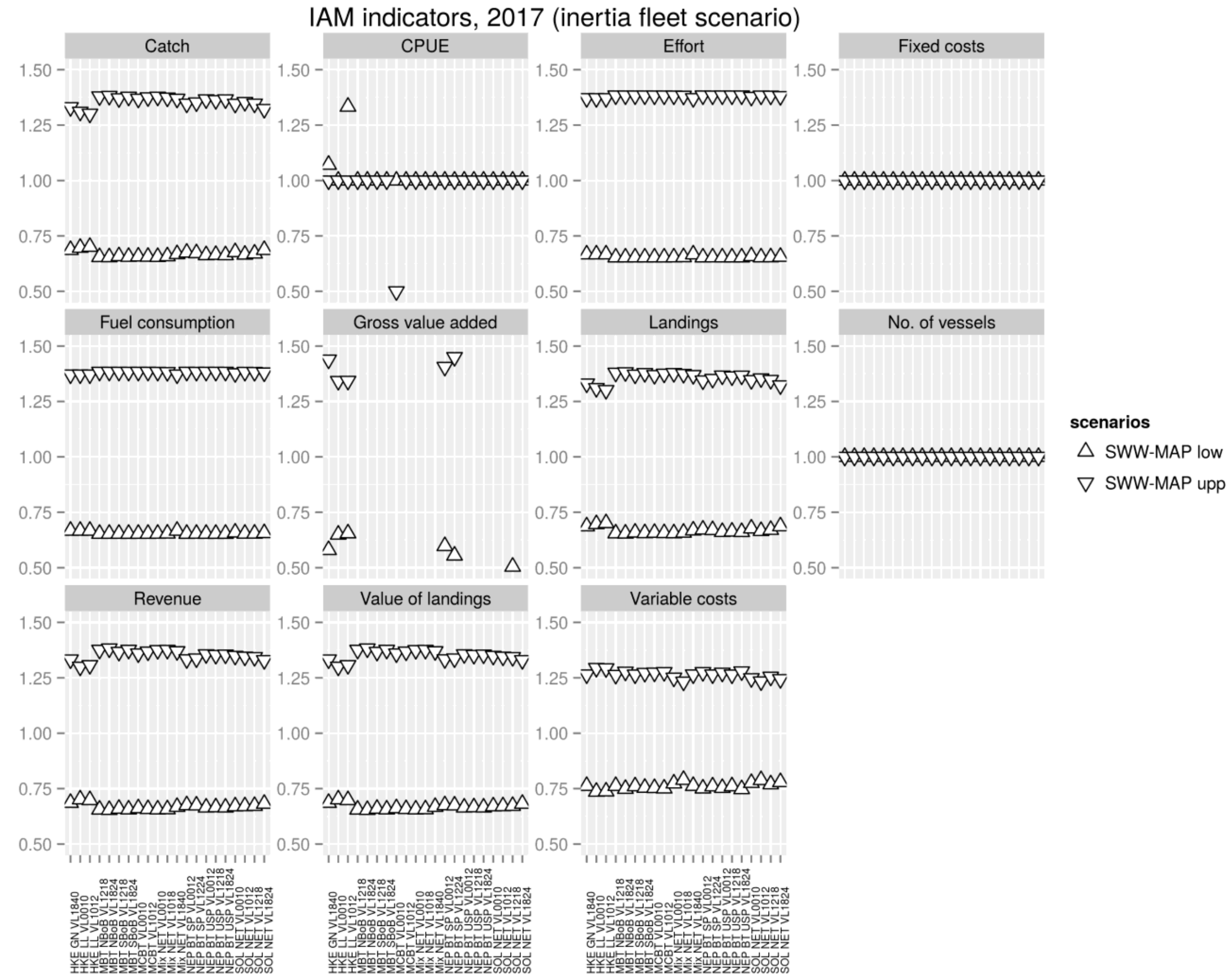

Figure 12. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Bay of Biscay, IAM) in 2017, and for 21 french fleets operating in the area.

With relation to the French demersal fleets operating in the Bay of Biscay, results show two groups of fleets:

- fleets specialized on hake (larger netters and longliners) that are not choked by sole and can increase or decrease F (and thus landings, effort, value of landings and costs) according to hake Fmsy ranges;
- fleets catching hake and sole for which F is constrained by sole.

Decrease in effort, landings and revenue by fleet observed is the results of the decrease of effort by fleet and métier according to reconciliation and fleets joint productions. As a result, we observe in the simulations that fleets specialized on hake (hake gillnetters and longliners) have lower decrease in effort than other fleets catching also for sole. Variability of impacts on hake fleets compared to baseline is lower than for other fleets. Economic impacts (positive or negative) will largely depend on fishing possibilities decided in the range of possible F.

Mixed bottom trawlers (12-18m in particular), characterized by mixed productions with low ability to adjust species correlations, would be the most impacted fleets, assuming no possible reallocation of effort and constant number of vessels. 2017 is the first year of transition phases and thus characterized by high negative impacts of scenarios compared to initial situation before recovery.

5.2.2 *State of the fisheries in 2021*

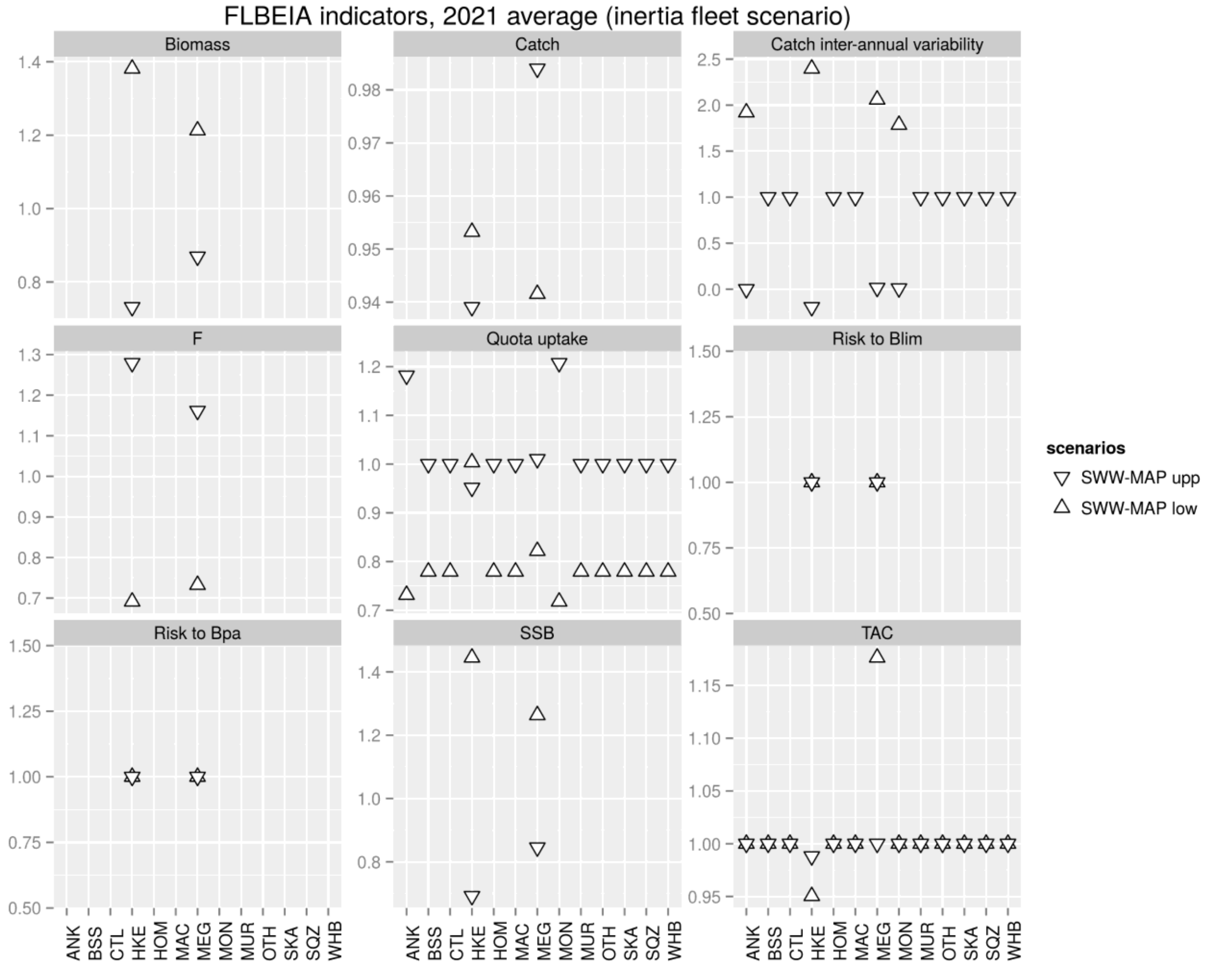

Figure 13. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Bay of Biscay, FLBEIA) in 2021, and for 13 stocks in the area.

Biomass is expected to be lower in the MAP-upp scenario and higher in the MAP-low scenario with relation to the baseline. The catches of hake and megrim are expected to be lower for both scenarios. In the case of hake there will be more catches in the MAP-low scenario than in MAP-upp. In the case of TACs, it is expected to be lower in both scenarios for hake and higher for megrim in the MAP-low scenario.

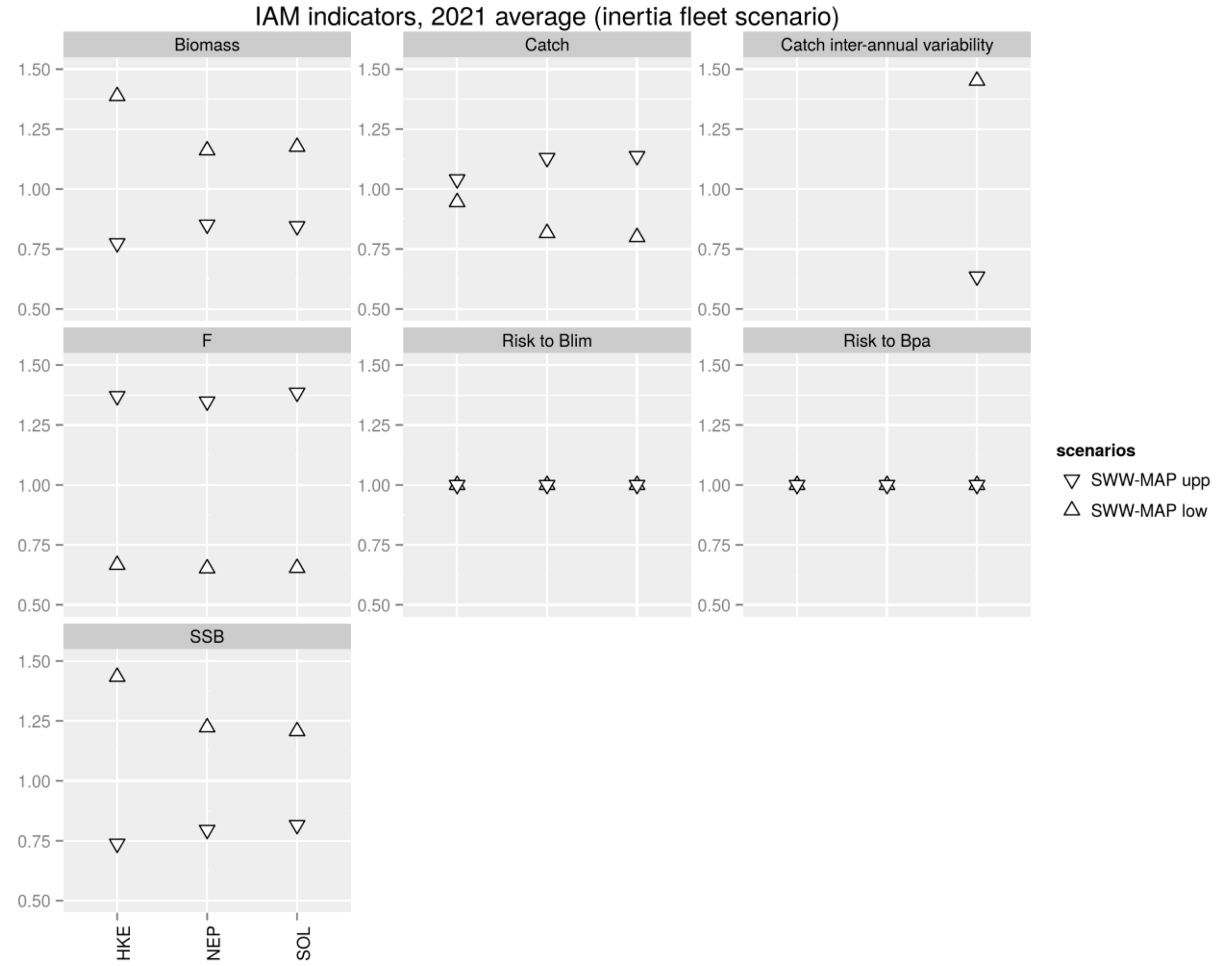

Figure 14. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Bay of Biscay, IAM) in 2021, and for three stocks in the area.

The results obtained by the IAM model in 2021 show higher SSB and biomass of sole, nephrops and hake the MAP-lowscenario as a result of decrease in F. Risk to Blim and Bpa are however not increased. Results show that F objectives for hake and sole are reached (or almost) for all the scenarios. It highlights that reconciliation of objectives for sole and hake is possible. Modeled fleets only account however for a part of the fishing mortality on hake and that choke effects for other non-explicitly modeled fleet is not taken into account. In the case of nephrops or sole, modeled fleets account for more than 90% of the total mortality on those stocks.

Decrease in F observed for nephrops is to be linked with management objectives for sole and hake, however it should be underlined that correlations between nephrops and sole are modeled in this application at the fleet-métier level and that spatio-temporal allocation of effort can modify correlation between species. Distribution of sole and nephrops landings thus show that landings of both species have low overlap and that there is possibility for fishermen to catch both species almost separately. Nephrops and hake are more joint by the spatial distribution of both species.

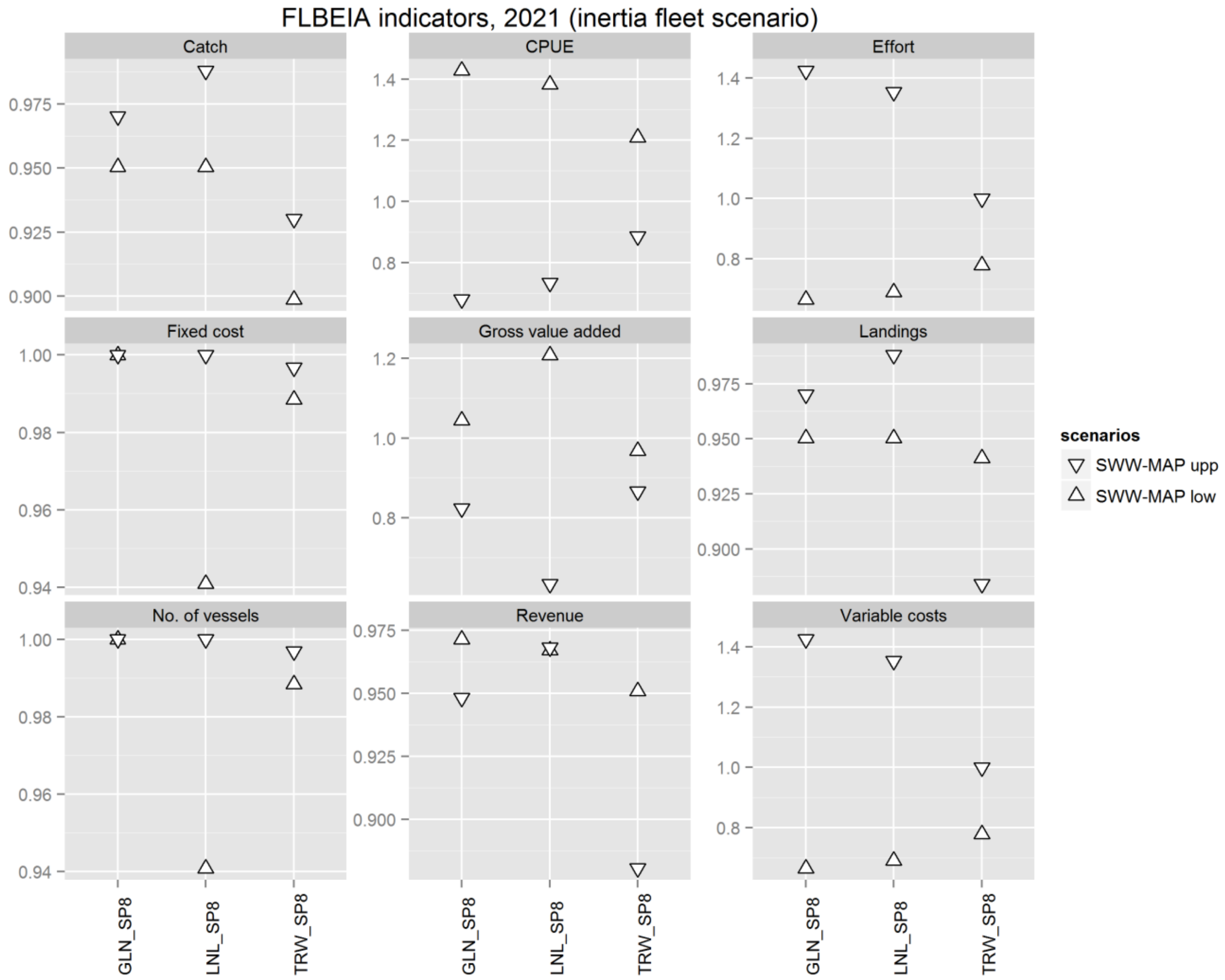

Figure 15. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Bay of Biscay, FLBEIA) in 2021, and for three fleets operating in the area.

The number of vessels is expected to be lower in the MAP-low scenario for Spanish longliners.

Revenues for the three fleets will be lower for both scenarios, reflecting the decrease in catches.

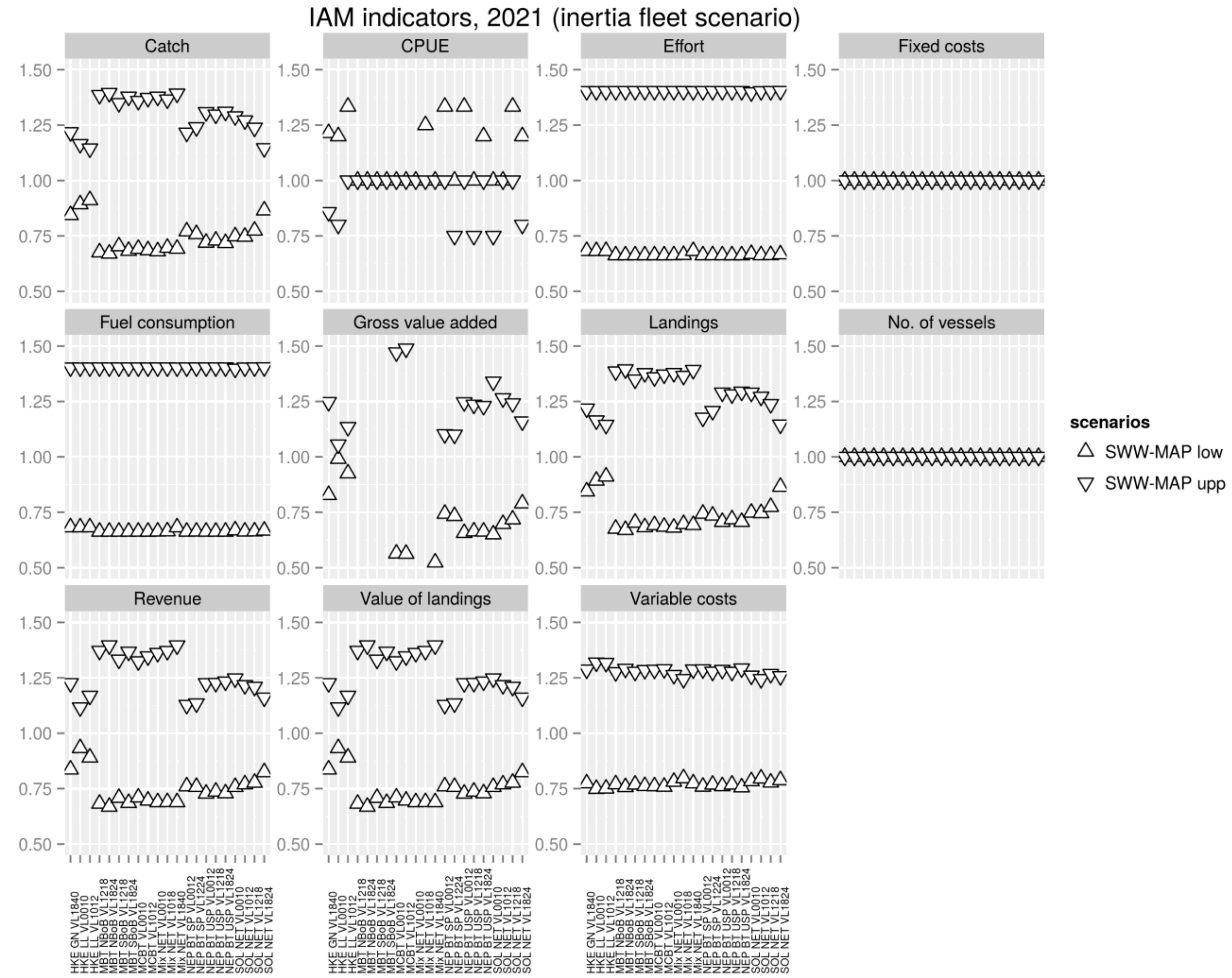

Figure 16. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Bay of Biscay, IAM) in 2021, and for 21 fleets operating in the area.

In 2021, the previous differences found between Flow and the baseline tends to decrease, as yields of Flow scenarios tend to increase due to the biomass increase. Improvement of fleets' performance compared to 2017 is observed for the Nephrops fleet, due to the biomass recovery (and assumption of no TAC constraints).

5.2.3 State of the fisheries in 2025

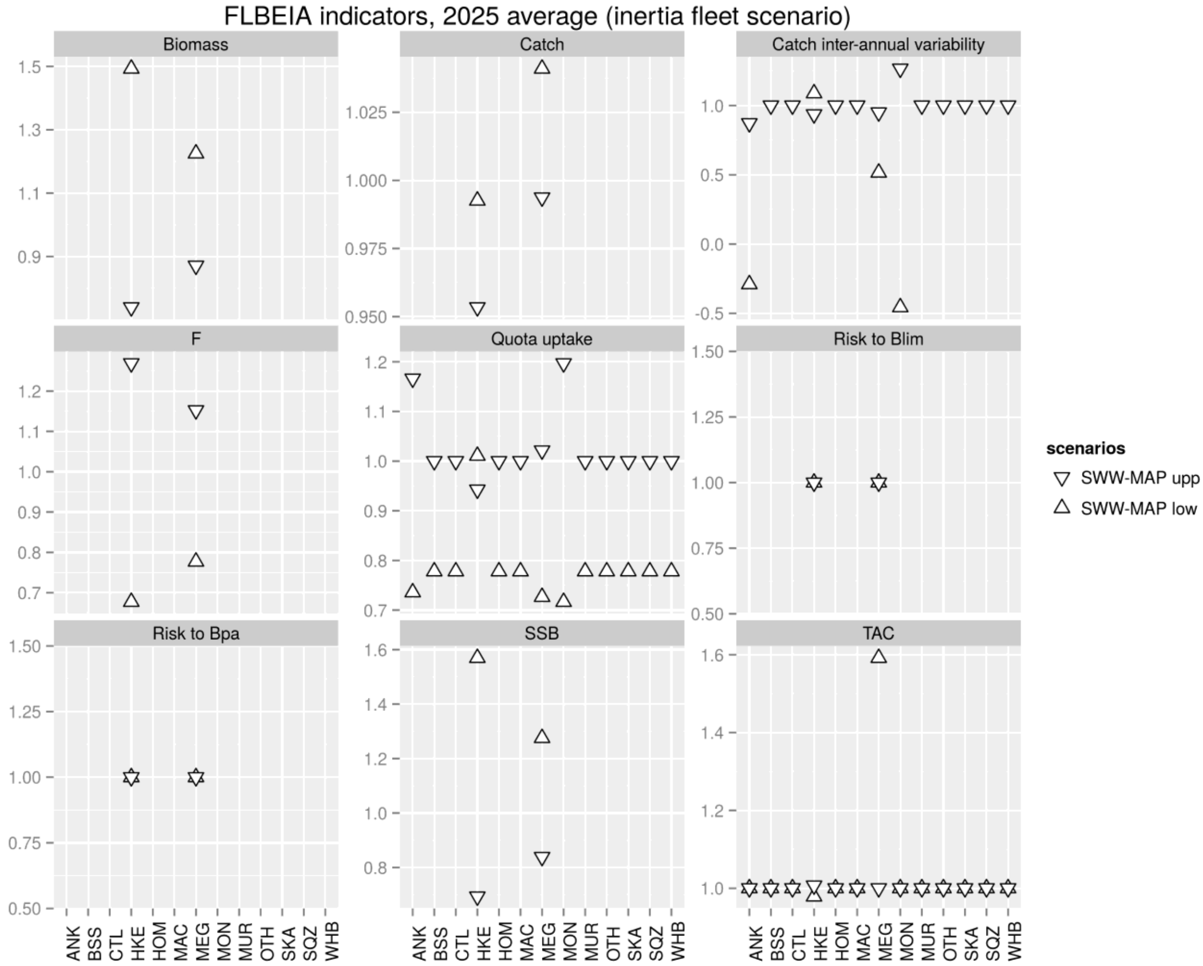

Figure 17. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Bay of Biscay, FLBEIA) in 2025, and for 13 stocks in the area.

The TAC for megrim is expected to be 60% higher for MAP-low scenario comparing with the baseline. As in 2021, the biomass is expected to be higher for the MAP-low scenario and lower for MAP-upp scenario, always above Blim and Bpa.

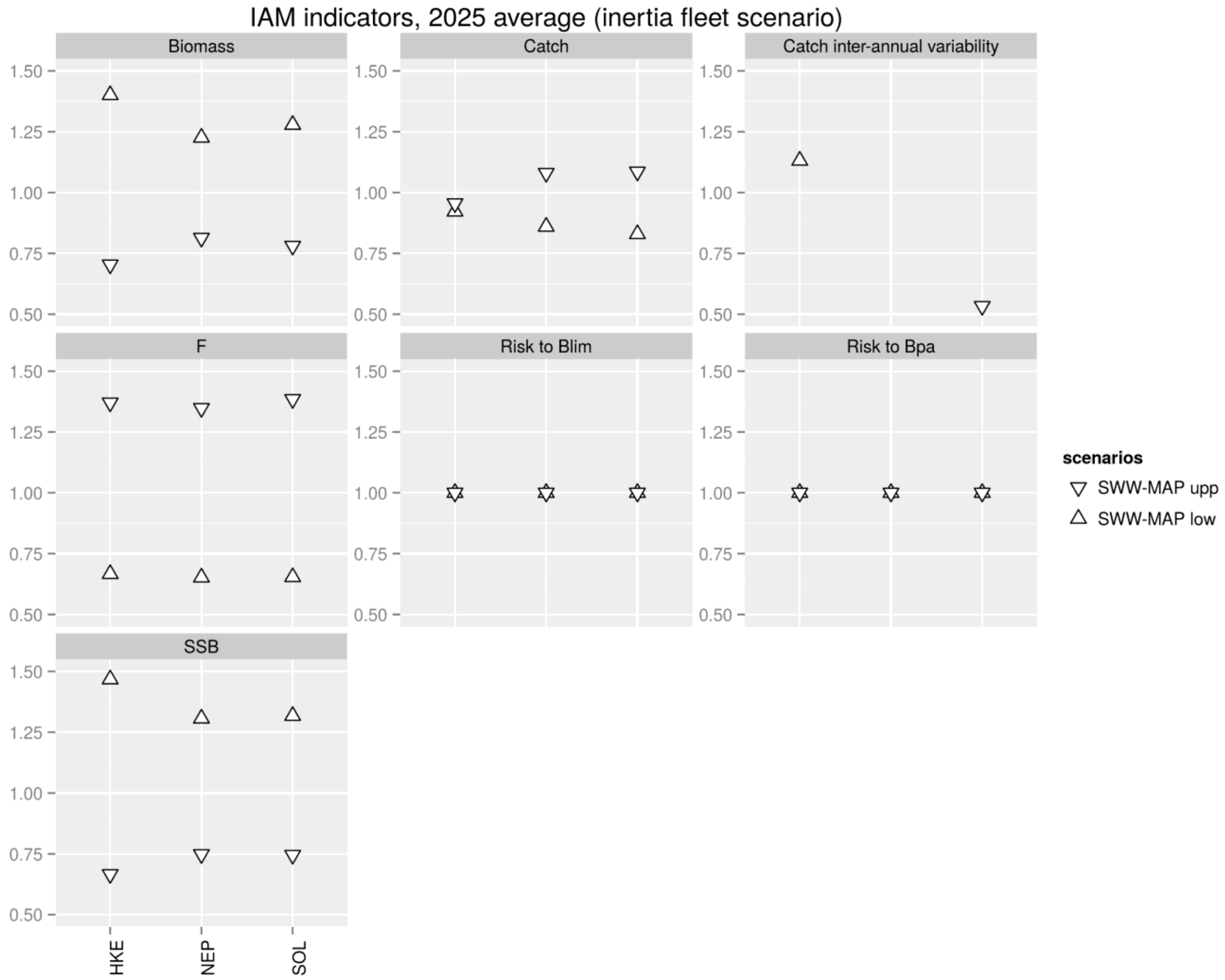

Figure 18. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Bay of Biscay, IAM) in 2025, and for three stocks in the area.

Trends observed in 2025 are similar as observed in 2021. Differences in Biomass, SSB and Catches between Fupp and Flow scenario compared to baseline are increasing due to fishing mortality applied to stocks.

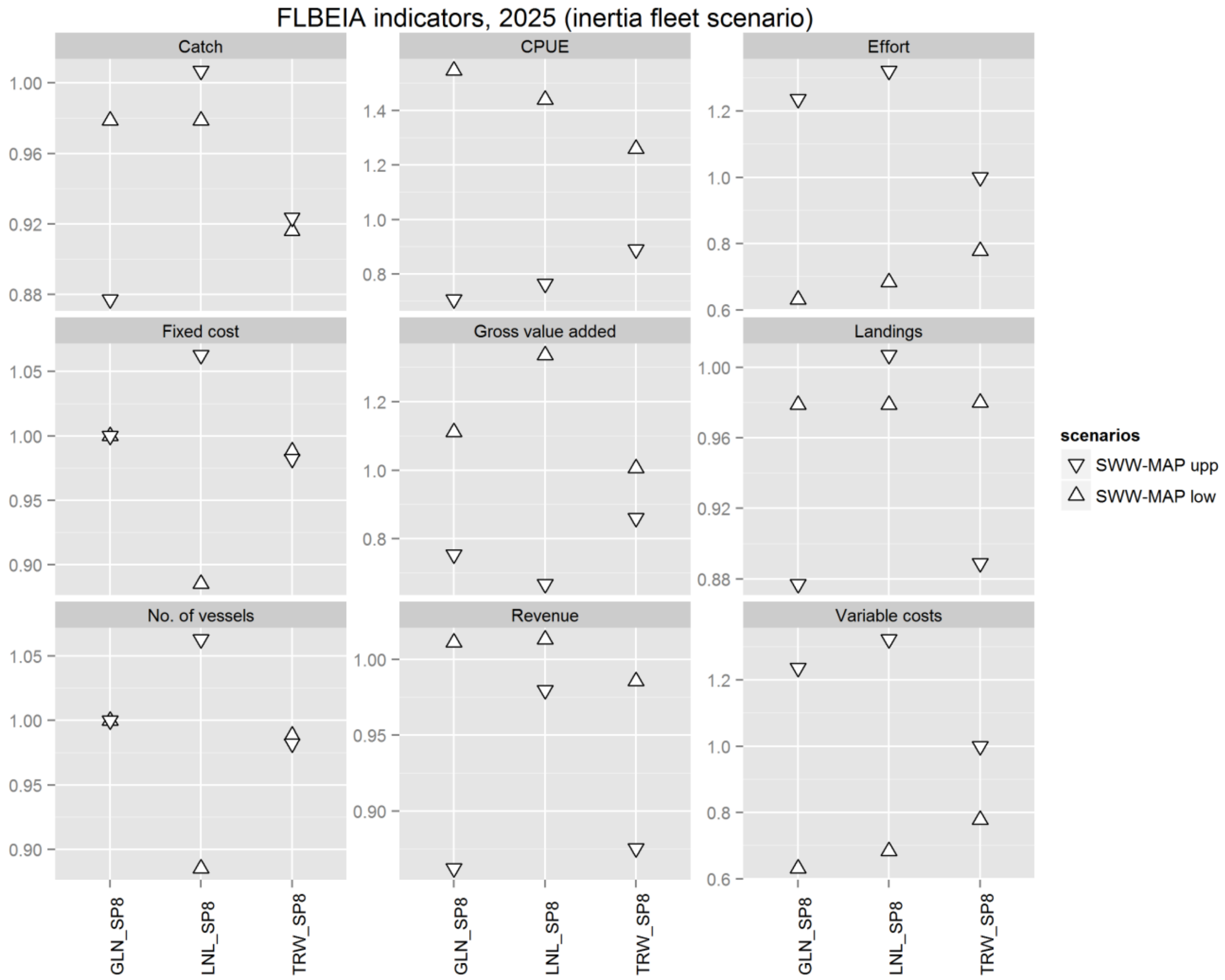

Figure 19. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Bay of Biscay, FLBEIA) in 2025, and for three fleets operating in the area.

In 2025 the differences between scenarios in economic indicators at fleet level are very similar to those observed in 2021.

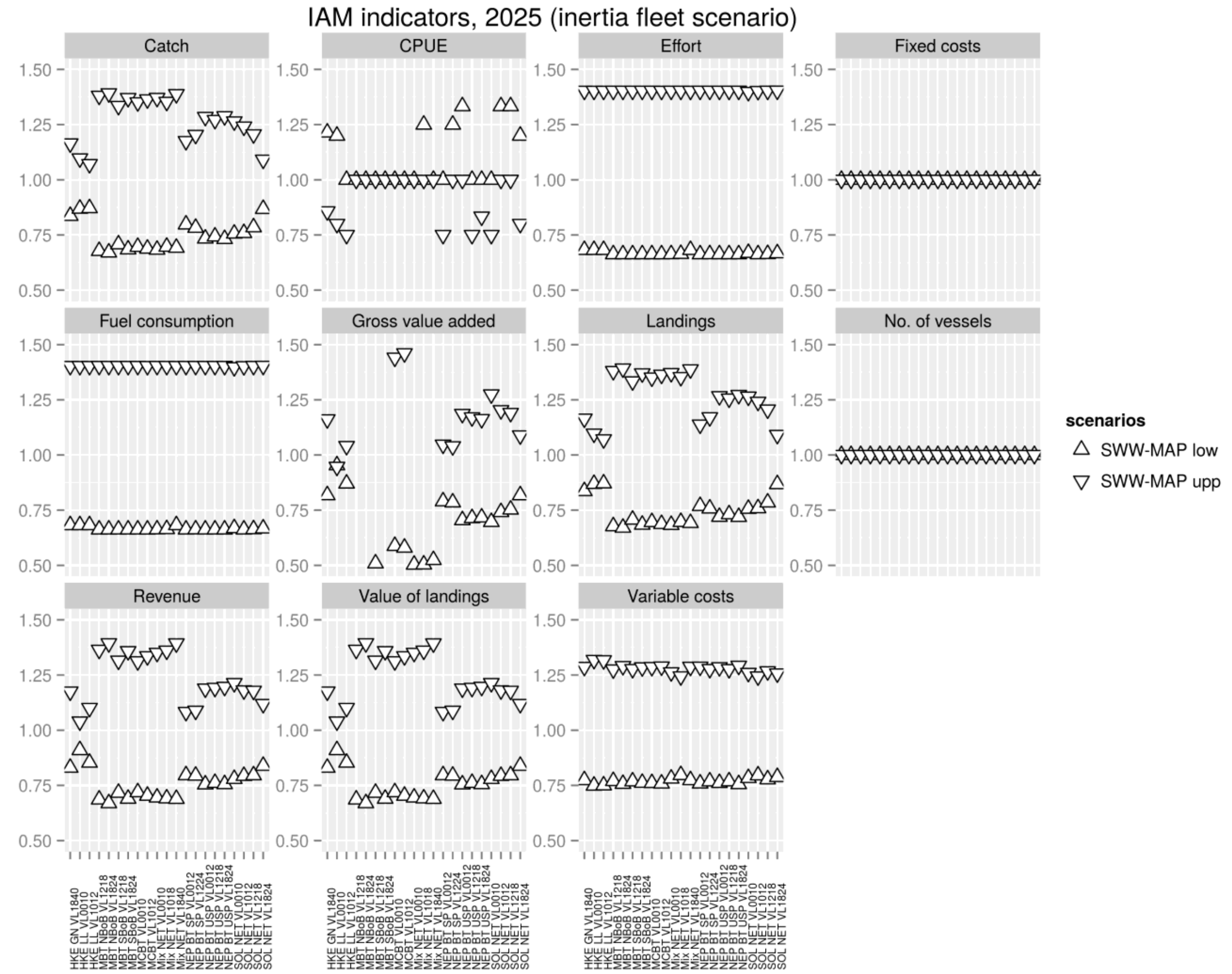

Figure 20. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Bay of Biscay, IAM) in 2025, and for 21 fleets operating in the area.

The trend observed in 2021 is still observed in 2025.

The results highlight the high ranges of possible economic impacts according to the scenario adopted and TAC decided within the envelope of possibilities. Assumptions of the models need to be kept in mind when analyzing the results. The constant number of vessels and absence of reallocation of effort limit the results obtained.

Differences in impacted fleets according to scenarios, depend mainly on:

- métiers by fleet, reconciliation process and choke effects assuming no possible reallocation of effort

- dependence and contribution to the different species managed and ability to benefit from stocks recoveries.

5.3 South Western Waters - Iberian Waters

5.3.1 State of the fisheries in 2017

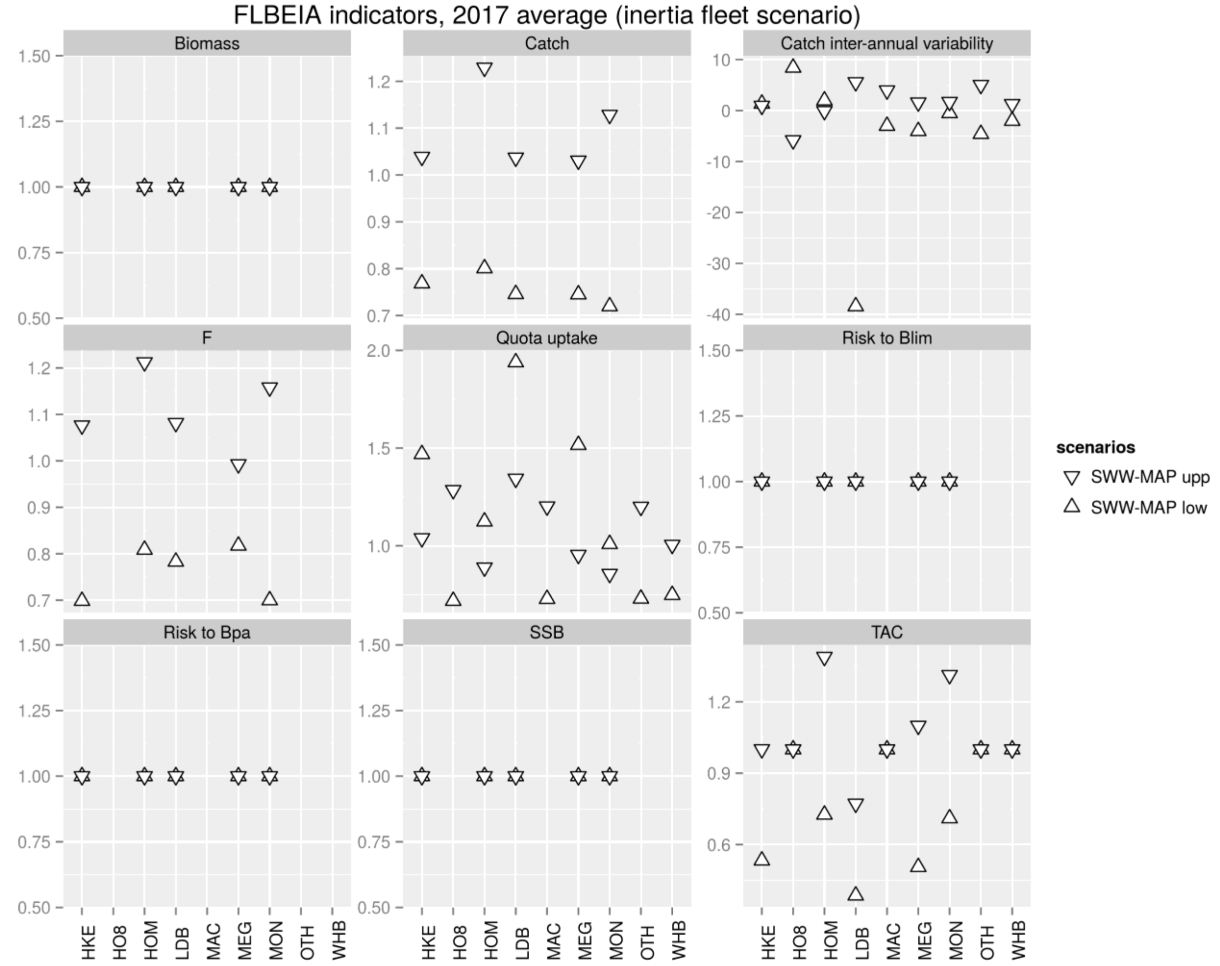

Figure 21. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Iberian Waters, FLBEIA) in 2017, and for nine stocks in the area.

The outlook for 2017 under the conditions described above shows that in relation to the baseline the biomass, ssb and biological risks are the same. As expected the TACs, fishing mortality and catch are higher in the MAP-upp scenario and lower in the MAP-low scenario. The quota uptake depends on the stocks, it is higher under MAP-low scenario for the stocks with dynamic (HKE, HOM, LDB, MEG and MON) and under MAP-upp scenario for the rest.

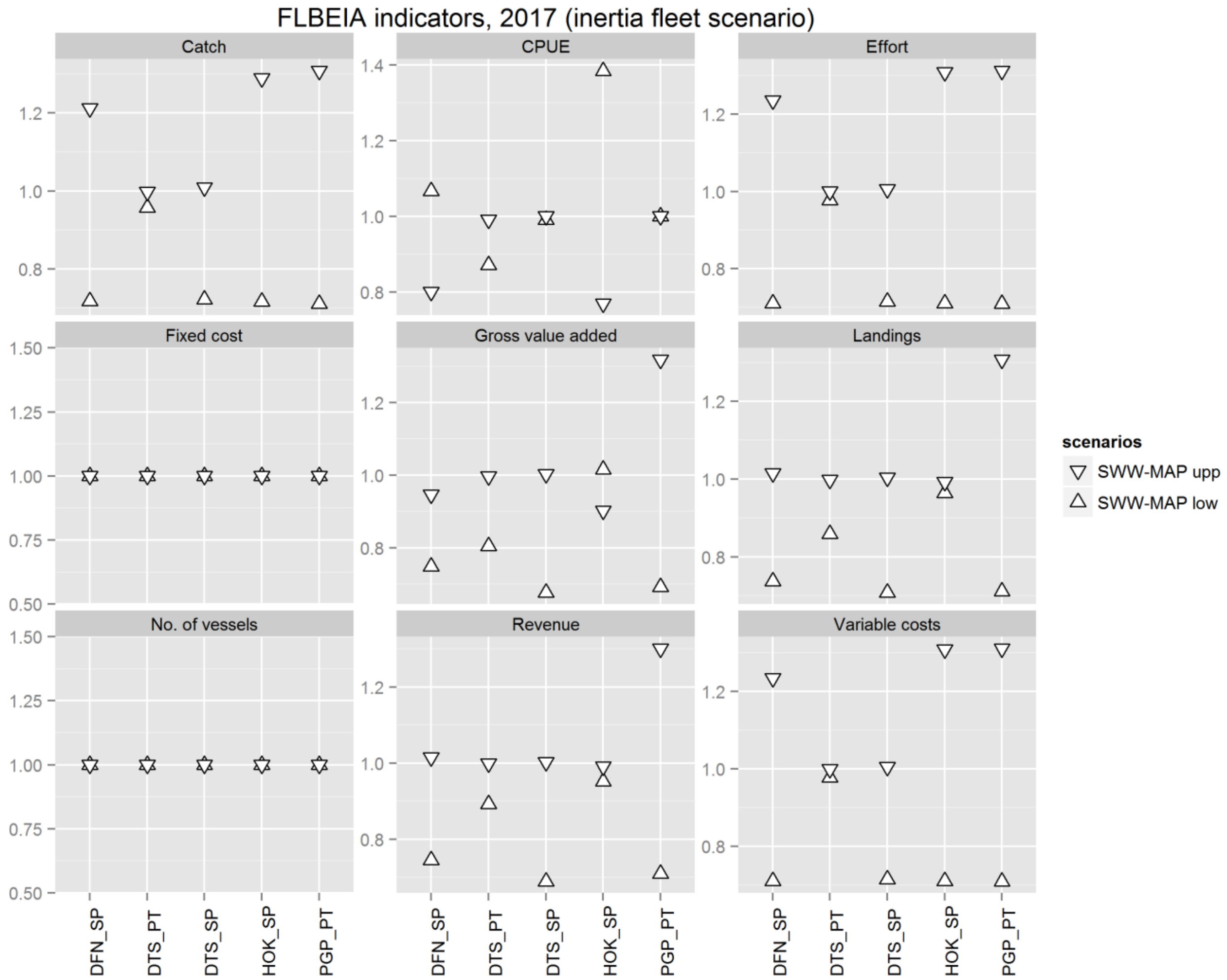

Figure 22. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Iberian Waters, FLBEIA) in 2017, and for five fleets operating in the area.

From a fleet perspective the results show fleet dependent effects. The effort and catch for Portuguese trawlers are similar in the three scenarios, but for the rest of the fleets the effort and total catch is up to 30% higher in MAP-upp scenario and around 25% lower in MAP-low scenario. The differences in landings are lower than in catch for all the fleets except for polyvalent gear fleet for which the differences are similar. Fixed costs are the same, once that the number of fleets in the fishery doesn't change. The economic indicators are in general higher in MAP-upp scenario but there are cases where the indicator is higher in MAP-lo scenario. For Spanish vessels using Hooks and Lines (HOK_SP) and Spanish fixed nets (DFN_SP), most economic indicators are higher in MAP-low scenario.

5.3.2 State of the fisheries in 2021

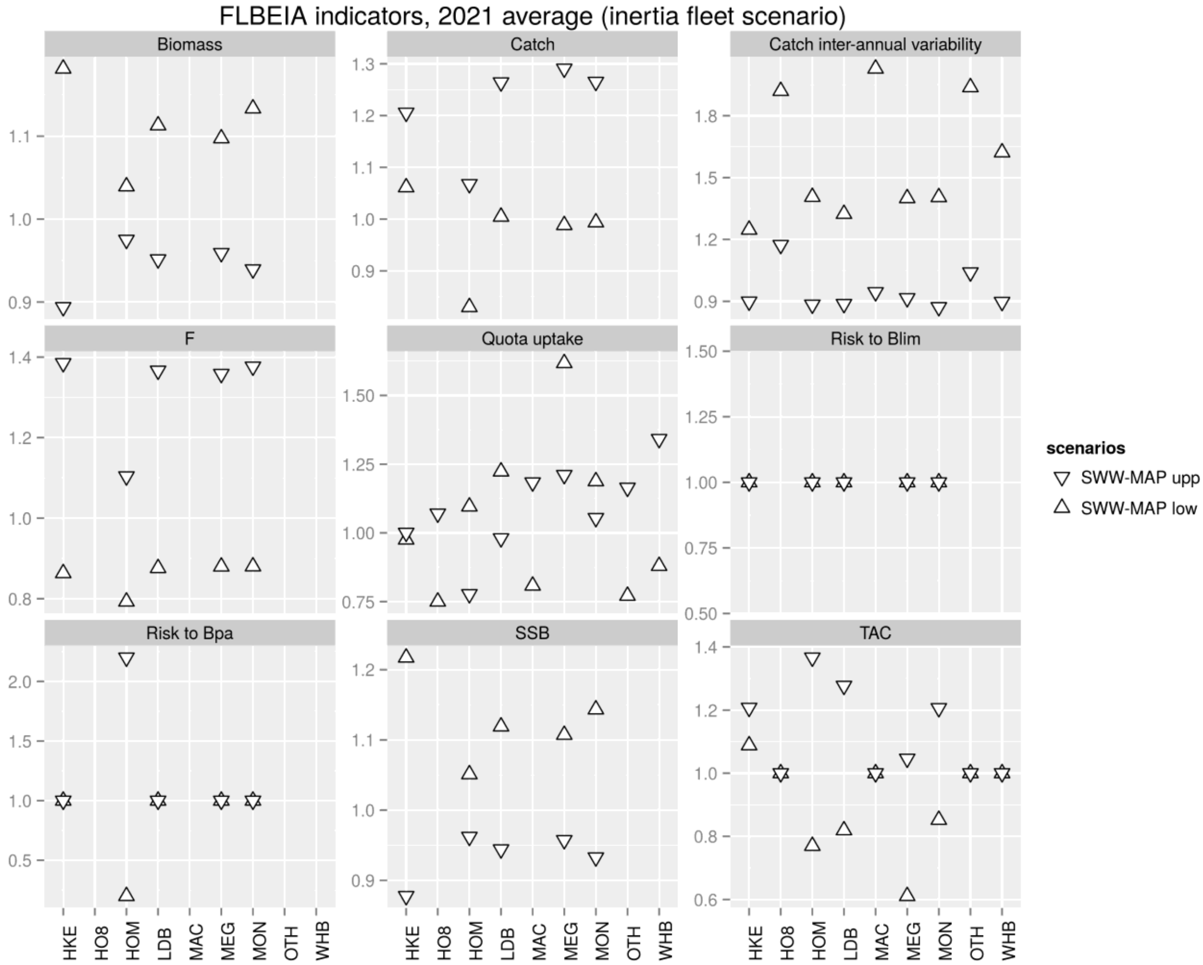

Figure 23. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Iberian Waters, FLBEIA) in 2021, and for nine stocks in the area.

In 2021 the differences in biological indicators between scenarios are higher. As expected biomass is always higher in MAP-low than in baseline scenario (>5-15%), and lower in MAP-upp scenario (up to 10%). Similar trends are observed for SSB. On the contrary fishing mortality is lower in MAP-low scenario (< 10-20%) and higher in MAP-upp scenario (~40% higher) than in baseline scenario for all the stocks except for Horse Mackerel (HOM)). The risk of SSB falling below Blim is null for all the stocks and the risk of falling below BPA is positive only for Horse Mackerel. For this stock the probability in MAP-upp scenario is double than in the baseline scenario and in MAP-low scenario is 75% lower. Total catch is up to 30% higher in MAP-upp scenario and in MAP-low scenario catch is only lower than in baseline scenario for Horse Mackerel (~15% lower). Inter-annual variability is always higher in MAP-low scenario. For stocks without dynamic the variability comes exclusively from the effort exerted by the fleets annually and for the rest is a product of the TAC advice. For the stocks with annual advice the variability is lower than for the rest of the stocks, 25% higher than in baseline in MAP-low scenario and 10% lower in MAP_upp scenario. Quota uptake depends greatly on the stock and scenario. The TAC is always higher in MAP-upp scenario and lower than in the baseline in MAP-low scenario for all the stocks except for Hake.

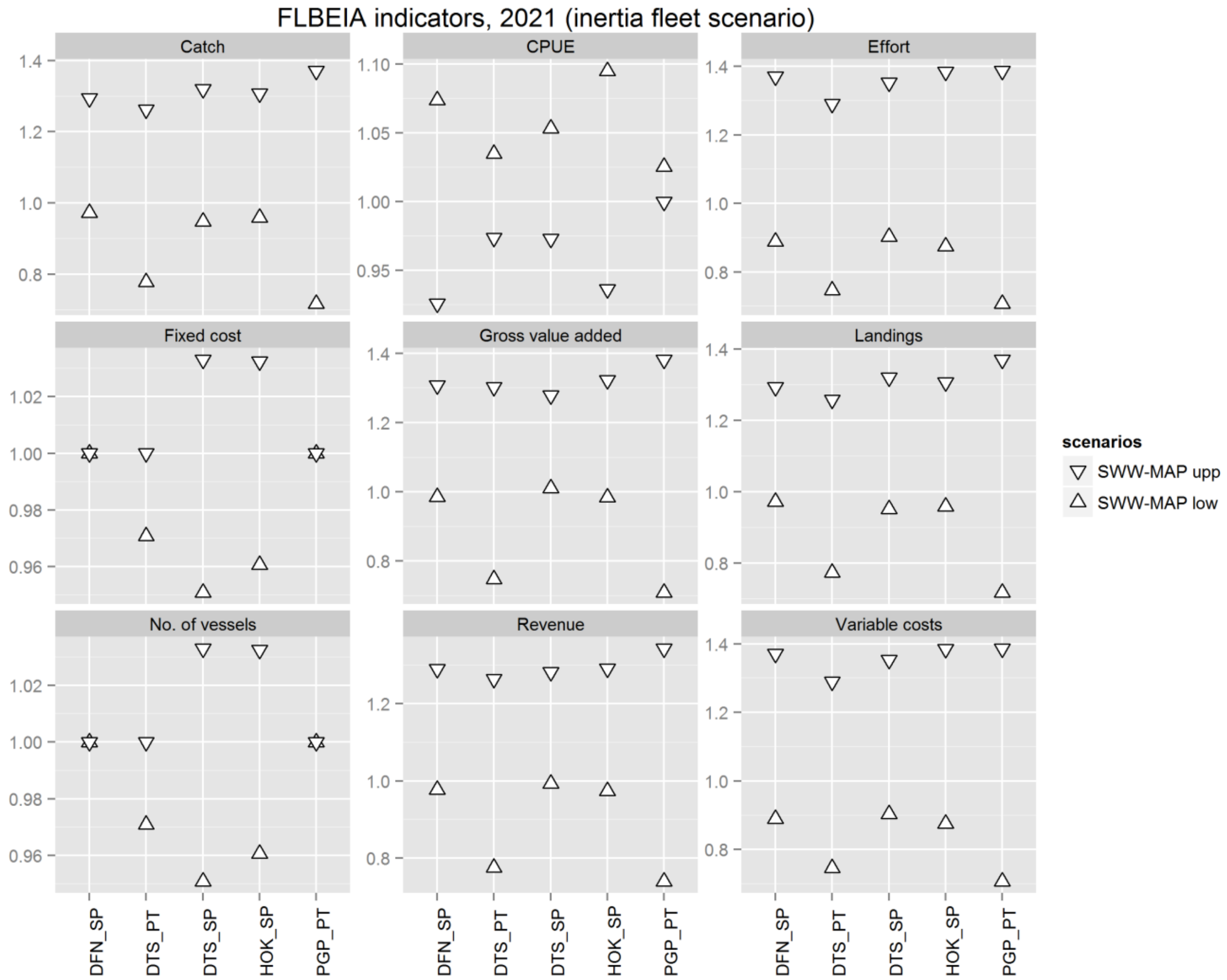

Figure 24. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Iberian Waters, FLBEIA) in 2021, and for five fleets operating in the area.

In 2021 all the indicators except fixed cost and number of vessels follow similar trends. They are all around 30% and 40% higher in the MAP-upp scenario than in the baseline. Regarding the MAP-low scenario for Spanish fleets (DFN_SP, DTS_SP and HOK_SP) the differences with the baseline are minimal. For the Portuguese fleets the differences are between 20% and 25%. In Spanish fixed nets (DFN_SP) and Portuguese polyvalent gears (PGP_PT) fleets the number of vessels is the same in all scenarios and so are the fixed costs. For Spanish Drift and Fixed Nets (DFN_SP) the number of vessels in the MAP_upp scenario does not change while for Spanish trawlers and Hook & liners (DTS_SP and HOK_SP) the number of vessels is 3% higher. In the MAP_low scenario the number of vessels decreases up to 5% in Spanish trawlers fleet (DTS_SP).

5.3.3 *State of the fisheries in 2025*

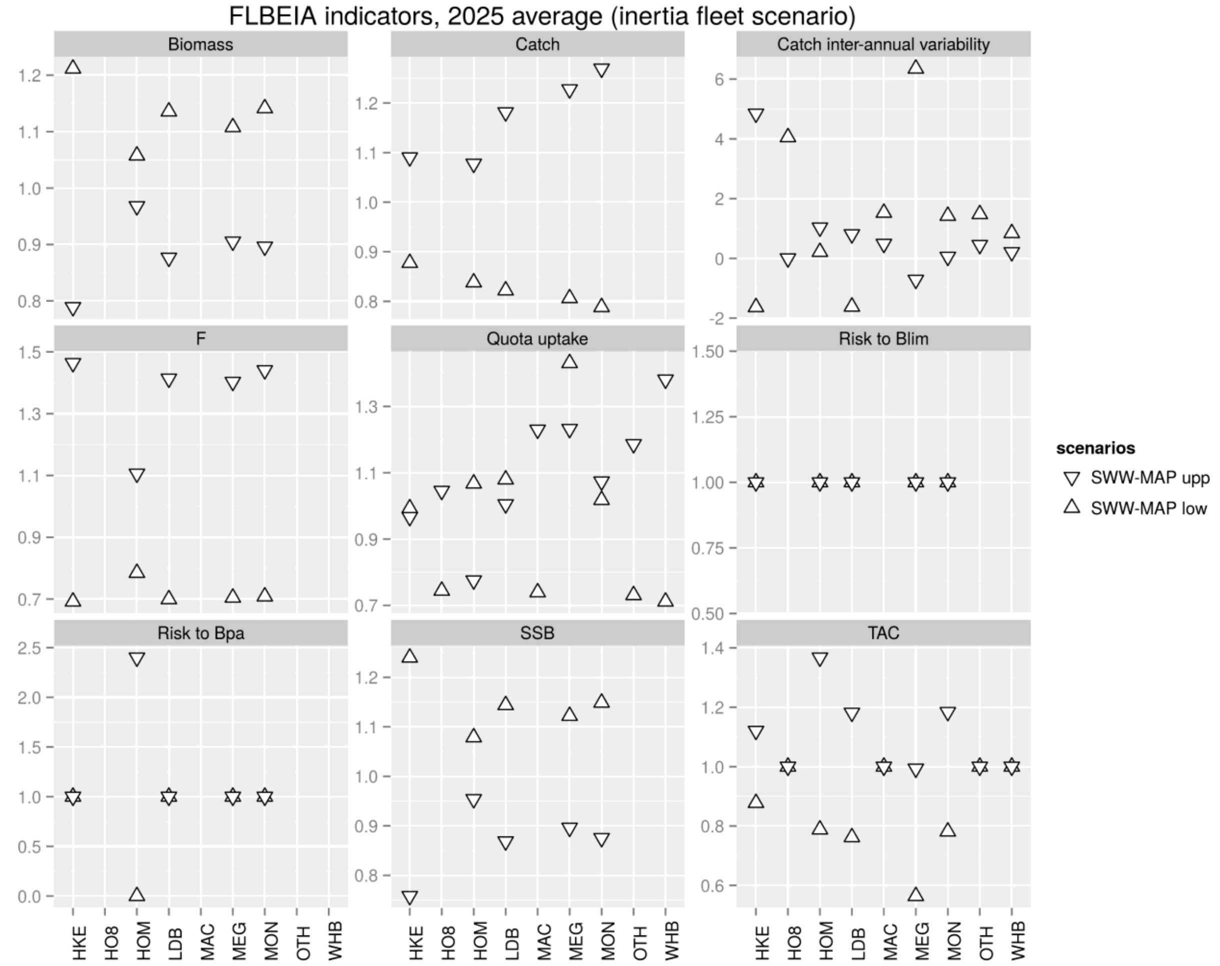

Figure 25. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Iberian Waters, FLBEIA) in 2025, and for nine stocks in the area.

In 2025 the differences between scenarios in Fishing mortality and biomass related indicators are similar to the differences in 2021. In the indicators related with catch the differences are in general higher. The catch in the MAP-low scenario is 10% to 20% lower than in the baseline and in the MAP-upp scenario from 10% to 30% higher. The differences in inter-annual variability are much higher than in 2021, trends also differ depending on the stock and scenario. For example, for Hake the inter-annual variability is 5 times higher in the MAP-upp scenario and for Megrim 6 times higher in the MAP-low scenario. The quota uptake is in the same range as in 2021. In 2025 the quota uptake in both MAP scenarios is similar and slightly higher than in the baseline. The differences in TAC are similar to those observed in 2021 except for hake. In 2025 the TAC for hake is 10% lower in the MAP_low scenario and 10% higher in the MAP_upp scenario than in the baseline.

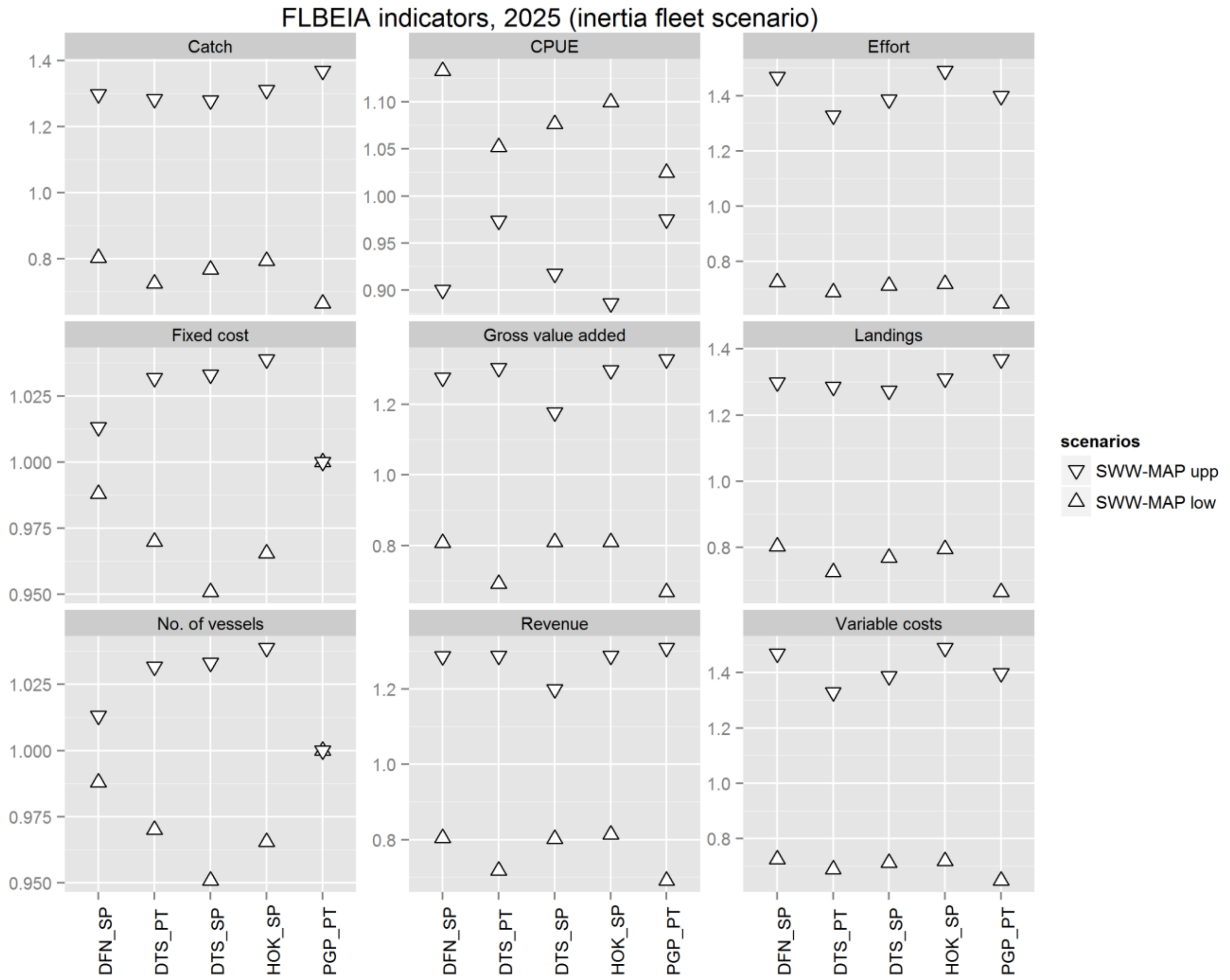

Figure 26. Ratios of various indicators for the upper and lower MSY ranges against the baseline (CFP) scenario, for the SWW MAP (Iberian Waters, FLBEIA) in 2017, and for five fleets operating in the area.

In 2021 the differences between scenarios in economic indicators at fleet level are very similar to those observed in 2021. The higher differences between these two years are observed in number of vessels and fixed costs. In 2025 the number of vessels in Spanish fixed nets fleet (DFN_SP) is slightly higher than in the baseline in MAP_upp scenario and slightly lower in MAP_low scenario. In the case of Portuguese trawlers (DTS_PT) the difference between MAP_upp and baseline increases in 2025 up to 2.5%. For the rest of the fleets the differences still the same as in 2021.

5.4 Employment and Dependency in the NWW

A dependency index of the fleets fishing in the North Western Atlantic waters (areas 27.6 and 27.7) for the main demersal stocks was calculated for 2012. The index was estimated by country and fleet segment (main fishing technique + vessel length). Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), European hake (*Merluccius merluccius*), Norway lobster (*Nephrops norvegicus*), European plaice (*Pleuronectes platessa*), common sole (*Solea solea*), whiting (*Merlangius merlangus*), megrims (*Lepidorhombus whiffiagonis* and *Lepidorhombus spp.*), and monkfishes (*Lophius piscatorius*, *Lophiidae*, and *Lophius spp.*) were previously identified as main demersal target species for the fleets fishing in the area of study.

The dependency index identifies the importance of a species from an economic point of view for a fleet. The index is built by dividing a species value of landings from a fleet segment by the fleet segment’s total value of landings.

We extracted the 2012 landings weight and value for these target species and totals by fleet segment from the 2014 Annual Economic Report (STECF, 2014) to estimate the indicator.

Table 7presents the fleet segments with the largest number of fishers employed in the Northeast Atlantic waters (area 27). The highest employment in Northeast Atlantic waters can be found with the <10m fleets, which would be expected, given the nature of these fleets; 7 of the top 10 fleets are <10m. Note that there are a number of fleets that didn't have all the information required and as such was not possible to include them in this analysis.

Table 7, Top 10 higher employment fleet segments in area 27

country	gear	Lenght	Total fishers employed
ESP	PGP	VL0010	4223
ESP	DRB	VL0010	4013
PRT	PMP	VL0010	2852
GBR	FPO	VL0010	2846
PRT	PGP	VL0010	2415
FIN	PG	VL0010	1834
ESP	DTS	VL2440	1632
ESP	HOK	VL2440	1595
EST	PG	VL0010	1538
ESP	PS	VL2440	1123
Total in the area			74297

However, only 3 of these top 10 fleets catch the target species in areas 27.6 and 27.7: UK's vessels using pots and/or traps of less than 10 meters, and Spanish demersal trawlers and long-liners between 24 and 40 meters.

Table 8 presents the fleet segments with the largest number of fishers employed that catch the target species in the areas 27.6 and 27.7. It is also reported on the table the degree of dependency the fleets have on the catch of these target species in the area.

Table 8. Top 10 higher employment fleet segments in area 27.6 and 27.7, and dependency indicator.

country	gear	length	Fishers employed	Dependency target spp.
GBR	FPO	VL0010	2846	15.6
ESP	DTS	VL2440	1632	23.1
ESP	HOK	VL2440	1595	32.2
GBR	DTS	VL1824	1080	30.7
GBR	DFN	VL0010	1011	33.8
GBR	DTS	VL1218	971	59.7
GBR	HOK	VL0010	860	2.8

GBR	DTS	VL2440	798	23.0
FRA	DTS	VL1824	783	38.3
NLD	TBB	VL40XX	734	0.0
Total general			74297	12.9

This table shows that most of the fleet segments with the largest number of fishers employed that catch the target species in the areas 27.6 and 27.7 have a high degree of dependency. Consequently, these target demersal species constitute a key source for their revenues. Significant decreases on these target demersal species landings, and so revenues would hamper the economic performance of these fleets and so their capacity to keep the current levels of employment.

Dependency and employment indicators for all fleet segments that catch the target demersal species are presented in the Annex VII. In the Annex, it is also reported the share each fleet catches the main demersal target species in area 27.6 and 27.7 in comparison to all area 27 catches.

5.5 Employment and Dependency in the SWW

4.4.1 High Employment Fleets

The highest employment can be found with the <10m fleets, which would be expected, given the nature of these fleets; 4 of the top 10 fleets are <10m, employing 13503 individuals. However, the dependency measure mostly indicates low dependency on the MAP target species in the SWW, except for the Spanish trawl fleet 24-40m and hook fleet 12-18m, which show moderate dependency, ~15%.

Table 9. Top 10 higher employment fleet segments with the number of employed people and dependency degree.

Fleet segment	Employment (No of employees)	Dependency (%)
ESP AREA27 PGP VL0010	4,223	2
ESP AREA27 DRB VL0010	4,013	0
PRT AREA27 PMP VL0010	2,852	0
PRT AREA27 PGP VL0010	2,415	5
ESP AREA27 DTS VL2440	1,632	14
ESP AREA27 HOK VL2440	1,595	8
ESP AREA27 PS VL2440	1,123	0
ESP AREA27 HOK VL1218	1,040	16
PRT AREA27 PS VL1824	1,002	0
ESP AREA27 PS VL1824	998	0

The demersal trawl fleets (DTS and TBB) also have high employment, with the top 10 fleets employing 6088 individuals (Table 4.4.3.2). Concerning dependency on the species in the MAP, the FRA trawl fleet 12-18m shows the highest dependency (40%), followed by the PRT fleets 18-24m and 12-18m (25% and 21%, respectively).

Table 10. Employment and dependency degree for the demersal trawl fleets

Fleet segment	Employment (No of employees)	Dependency (%)

ESP AREA27 DTS VL2440	1,632	14
FRA AREA27 DTS VL1824	783	5
FRA AREA27 DTS VL1218	619	40
PRT AREA27 DTS VL2440	567	10
IRL AREA27 DTS VL1824	441	0
ESP AREA27 DTS VL1824	425	9
FRA AREA27 DTS VL2440	423	1
ESP AREA27 DTS VL40XX	404	1
PRT AREA27 DTS VL40XX	403	0
FRA AREA27 DTS VL1012	391	19
ESP AREA27 DTS VL1218	336	4
IRL AREA27 DTS VL2440	288	0
GBR AREA27 DTS VL40XX	203	0
PRT AREA27 DTS VL0010	180	6
IRL AREA27 DTS VL1218	179	0
BEL AREA27 TBB VL2440	166	7
FRA AREA27 DTS VL0010	133	14
PRT AREA27 DTS VL1218	66	21
PRT AREA27 DTS VL1824	53	25
PRT AREA27 DTS VL1012	36	5

4.4.4 Low Employment Fleets

23 fleets employ less than 100 individuals. The majority of these fleets belong to France (10) and Portugal (8).

The dependency on landings of the MAP target species varies significantly among gear type, boat length, and MS. The French fleet using other active gears (FRA MGO VL1012) presents the highest dependency (44%) and is one with the lowest employment. 7 fleets show dependency on the MAP target species between 10 and 25%. These include fleets from all length groups, using all type of gears, belonging to France (3), Portugal (3) and Spain (1).

Six fleets have no dependency on the MAP target species. They are 2 fleets with dredges (PRT and ESP), 2 with drift or fixed nets (GBR and DEU), 1 using pots or traps (FRA) and 1 with pelagic trawl (DNK).

Table 11. Fleet segments with the number of employees < 100 and dependency degree.

Fleet segment	Employment (No of employees)	Dependency (%)
FRA AREA27 MGO VL1012	7	44
PRT AREA27 DTS VL1824	53	25
PRT AREA27 DTS VL1218	66	21
FRA AREA27 PGP VL1012	15	16
FRA AREA27 PMP VL1218	32	13
ESP AREA27 HOK VL0010	18	13
FRA AREA27 PGP VL0010	87	12
PRT AREA27 FPO VL1824	56	10

PRT AREA27 HOK VL1012	54	8
FRA AREA27 TM VL1218	58	8
FRA AREA27 TM VL1012	15	7
PRT AREA27 PGP VL1012	32	6
PRT AREA27 DTS VL1012	36	5
FRA AREA27 MGP VL0010	21	4
FRA AREA27 MGP VL1012	70	2
FRA AREA27 MGP VL1218	74	2
PRT AREA27 DRB VL1012	58	1
PRT AREA27 DRB VL1218	54	0
GBR AREA27 DFN VL1218	77	0
FRA AREA27 FPO VL1824	85	0
ESP AREA27 DRB VL1012	36	0
DNK AREA27 TM VL40XX	94	0
DEU AREA27 DFN VL2440	77	0

4.4.5 Highest Dependency Fleets

Table 4.4.5.1 presents the 13 fleets showing the highest degree of dependency on the MAP target species (≥ 20%). The total number of people employed by these fleets is 3 780. These fleets include 9 using drift and fixed nets (FRA – 4, ESP – 3, PRT – 2), 3 trawl fleets (PRT – 2, FRA – 1) and 1 using other active gears (FRA). All length segments are involved.

Table 12. Fleets with highest dependency (≥ 20%)

Fleet segment	Employment (No of employees)	Dependency (%)
ESP AREA27 DFN VL2440	117	51
FRA AREA27 DFN VL1824	278	48
FRA AREA27 MGO VL1012	7	44
FRA AREA27 DFN VL1218	330	41
FRA AREA27 DTS VL1218	619	40
PRT AREA27 DFN VL1824	351	35
ESP AREA27 DFN VL1824	342	32
FRA AREA27 DFN VL2440	327	31
PRT AREA27 DTS VL1824	53	25
ESP AREA27 DFN VL1218	588	23
PRT AREA27 DTS VL1218	66	21
FRA AREA27 DFN VL1012	579	20
PRT AREA27 DFN VL1012	124	20

STECF, 2013. The 2013 Annual Economic Report on the EU Fishing Fleet (STECF-13-15). Publications Office of the European Union, Luxembourg, EUR 26158 EN, JRC 84745, 302 pp.

5.6 Reconciling TACs by using FMSY ranges

A state-space model was designed to compute fishing mortality as the "endogenous" result of the fleets' responses to the management measures. In the Annex V we show how fishing mortality interactions can be modelled as simple "state dependents" variables in a multi-fleet age-structured model. The model can be used to simulate the size of the fishing mortalities fluctuations around reference (equilibrium) targets.

The state-space multi-fleet model was calibrated to match 2012 *Fbar* levels of the Southern Stock of hake for four species: hake, megrim, four-spot-megrim and monkfish. A vector autoregressive (VAR) model was used for the analysis of recruitments time series.

Two scenarios were simulated. In the first scenario, fleets' behaviour was projected assuming that the response of the fleets will not be affected by management regulations. In the second scenario, the size of fluctuations is reduced to minimize (simultaneously) the distance of the four *Fbar* values to the target.

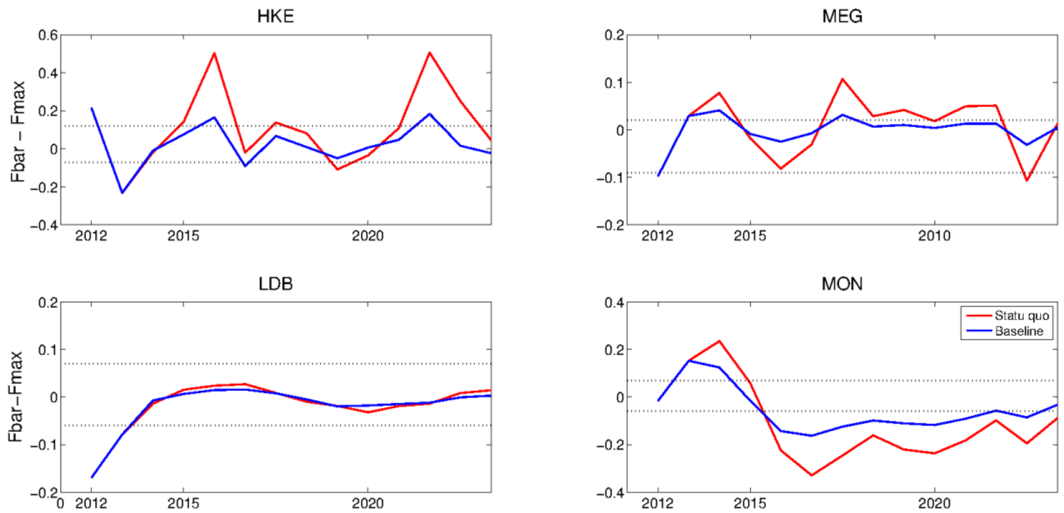

Figure 27. Endogenous Fbar fluctuations around the target. The y-axis and x-axis plot the deviation of Fbar from the target and the time, respectively. The horizontal lines represent the Fbar Ranges of each species.

Figure 27 shows the endogenous *Fbar* fluctuations generated by the model. The y-axis plots the deviation of *Fbar* from the target, and the x-axis, time. Note that differences in the recruitment variability (measured by the variance covariance matrix of the VAR process) and the existence of technical fishing interactions (captured in the state-space model) generate differences in the "natural" fluctuations of each species.

The figure clearly shows that a management procedure that tries to reconcile the several F targets simultaneously can be more successful achieving the single species targets defined in the CFP. Additionally it shows that the *Fmsy* ranges will accommodate most of the natural fluctuation introduced by recruitment.

6 ToR 3.4 – Number and scope of MAPs

The MAP, as a strategic tool of the CFP, sets tactical objectives to achieve the CFP goals. The contents of the MAP, as defined in Artº 10.1, can be grouped into measures that relate to the stocks (a-e,g) and measures that relate to the fleets (f).

The first set includes objectives regarding the exploitation of the stocks and risk-avoiding actions. The agreement between the Council, the Parliament and the Commission, translated those into Fmsy ranges, biomass safeguards and recovery periods for each stock (ref).

The second set is related with the implementation of landing obligations (Artº 15) and should operate at a local level, adjusted to the fleet(s) dimension. These are technical measures, quota allocation and others measures to reduce unwanted catches.

From the point of view of the stock measures, having MAPs with a wider scope would limit both the number of stocks that will have to be split across regulations and the potential inconsistencies that may arise from having to make several regulations coherent. Nevertheless, it still remains largely a policy decision if the implementation of MAPs is better regulated by one, two or more regulations. As long as the objectives are still followed and the biomass safeguards applied, the outcomes of MAPs designed under the current framework, should not be impaired by their scope.

When considering fleet measures, the spatial scope is largely dependent on the fleet composition and the technical characteristics of the vessels. In such cases, having MAPs that focus on more homogenous regions, like the Bay of Biscay or Iberian waters, may encourage buy-in by Member States and regional/local bodies and establish a more homogeneous playing field.

7 ToR 3.5 – Fishery approach NWW

Landings discard rates data from the FDI database (STECF, 2013) were used to calculate the correlation between catches of species in the ICES divisions 7bcefghjk. The correlations between target and by catch species are calculated on year 2003 to 2012. A threshold of ten tons of catches over the time period was applied to remove insignificant species. The data provides a detailed image of the catches and catch composition of the different gears operating in these areas.

Catches of cod, haddock and hake appear positively correlated with megrim (LEZ), anglerfish (ANF), surmullet (MUR), witch flounder (WIT), common mora (RIB), tope shark (GAG), plaice (PLE) horse mackarel (JAX), scallop (SCE), turbot (TUR) and herring (HER) (i.e. those with correlation superior to 0.5) and negatively correlated with smooth hound (SDV), tusk (USK), horse mackerel (HOM), Raja rays (SKA), gunards (GUX), catsharks (SCL), brill (BLL), John dory (JOD), rays (SRX), blackbanded trevally (RNJ), surmullets (MUX), Red gurnard (GUR), megrim (MEG), lobster (LBE), Porbeagle (POR), edible crab (CRE), common squid (SQC), spotted reay (RJM) and common cuttlefish (CTC) (i.e., those with correlation inferior to -0.55). Sole and saithe are weakly correlated to the other species catches (correlation coefficient rarely higher than 0.5 and 0.8 respectively).

Using the STECF database it was also possible to assess the yearly catch assemblage of the different gears and test for correlation between the level of catches of the target species and catches of the other species in the database. All targeted species and by catches do not appears for each gear type, which brings information on the species caught by each gear.

Table 13. Correlation matrix at the specie and area level. Target species are in column and by catch species in row. This is a subset of the matrix showing correlation coefficient higher that |0.5|.

	COD	HAD	HKE	NEP	POK	SOL	WHG
LEZ	0.91	0.78	0.86	-0.55	0.44	0.11	-0.27
ANF	0.84	0.66	0.81	-0.27	0.44	0.14	0.07
MUR	0.83	0.62	0.8	-0.46	0.63	0.35	-0.06
WIT	0.76	0.66	0.73	-0.45	0.88	0.59	0.09
RIB	0.72	0.88	0.71	-0.34	0.59	0.2	-0.22

GAG	0.68	0.69	0.78	-0.37	0.32	0.35	-0.15
PLE	0.68	0.62	0.62	-0.37	0.4	0.06	-0.24
JAX	0.61	0.75	0.51	-0.74	0.32	-0.16	-0.37
SCE	0.61	0.55	0.68	-0.35	0.34	0.63	-0.02
TUR	0.59	0.78	0.54	-0.45	0.82	0.35	-0.11
HER	0.5	0.29	0.48	-0.28	0.75	0.73	0.17
CTC	-0.55	-0.53	-0.47	0.52	0.12	0.35	0.55
RJM	-0.55	-0.54	-0.5	0.51	-0.03	0.26	0.35
SQC	-0.55	-0.55	-0.48	0.5	0.09	0.37	0.46
CRE	-0.55	-0.65	-0.43	0.72	-0.11	0.24	0.53
POR	-0.58	-0.47	-0.48	0.56	0.13	0.15	0.47
LBE	-0.58	-0.71	-0.48	0.68	-0.12	0.28	0.48
MEG	-0.59	-0.64	-0.5	0.62	-0.06	0.31	0.47
GUR	-0.59	-0.67	-0.45	0.66	-0.06	0.4	0.54
MUX	-0.6	-0.6	-0.43	0.68	0.03	0.33	0.61
RJN	-0.6	-0.6	-0.5	0.6	-0.05	0.28	0.38
SRX	-0.6	-0.62	-0.37	0.79	-0.04	0.14	0.54
JOD	-0.62	-0.66	-0.51	0.66	-0.07	0.29	0.42
BLL	-0.63	-0.68	-0.5	0.73	-0.12	0.24	0.48
SCL	-0.63	-0.7	-0.5	0.73	-0.13	0.25	0.49
GUX	-0.63	-0.74	-0.49	0.76	-0.2	0.25	0.46
SKA	-0.63	-0.77	-0.51	0.75	-0.24	0.21	0.59
HOM	-0.64	-0.63	-0.49	0.71	-0.17	0.12	0.29
LSK	-0.65	-0.77	-0.47	0.83	-0.33	0.14	0.33
SDV	-0.66	-0.75	-0.48	0.85	-0.27	0.12	0.42

Looking at a more detailed aggregation shows that the relationships between the target-bycatch dynamics are stronger at the fleet level than the stock or métier level. For example, at the species/TAC level the expected correlation between sole and plaice is very weak whereas it appears quite clearly for several gear (Table 14).

Table 14. Sole and Plaice correlation for different gears

	BT2	OTTER	TR1
PLE-SOL	0.3	0.72	0.7

Detailed analysis of this table illustrate the difficulty in management such a multi species and multi fleet fisheries. For example, management of the target species should positively impact anglerfish catches for trawlers (TR1, TR2, Otter and BT2) but the gillnets fleet it is the reverse Table 15.

As discussed in the EWG NSMAP 15-04 report, It should be noted that in the effort database, catches are aggregated over years, métiers and areas. However, fleets and species move during the year (changing fishing ground, spawning migrations, etc) which means that observed correlations might not reflect real technical interaction. Correlations between levels of catches of the main species and the "other species" presented here should be taken as indicative of the potential impact of management on species caught by the different gears.

Table 15. Correlation between catches of anglerfish with the main target species for different gears.

GT1

	HKE	WHG	COD	POK	SOL		
ANF GN1	-0.43	-0.51	-0.25	-0.02	-0.11		
	HKE	SOL	COD	POK	HAD	WHG	
ANF TR3	-0.4	0.52	-0.14	-0.27	-0.28	-0.12	
	HAD	WHG					
ANF TR2	0.59	0.24					
	COD	SOL	NEP	WHG	HAD	HKE	POK
ANF TR1	-0.15	-0.21	0.38	0.57	0.42	0.68	0.61
	HAD	COD	WHG	SOL	HKE	POK	NEP
ANF OTTER	0.89	0.9	0.72	0.47	0.82	0.58	-0.23
	POK	COD	HAD	WHG	HKE	SOL	
ANF BT2	0.59	0.64	0.86	0.64	0.71	0.57	
	HAD	COD	WHG	SOL	HKE		
ANF	0.77	0.39	-0.31	-0.42	-0.59		

8 ToR 3.5 – Fishery approach SWW

The data for the analysis was extracted from the STECF effort database (EWG 14-13: Fishing effort Part 2 [http://stecf.jrc.ec.europa.eu/data-reports]). The availability and aggregation level of data have determined the selection of species and years for the correlation exercise. For the same reason, an adaptation of the list of fisheries for the SWW MAP detailed in the request to STECF has been done. It was not possible to analyze Pair and Otter-trawl fisheries separately because in the database they are aggregated under the Trawl category. It was also not possible to identify the fishery of plaice in IXa operated by trammel netters because no landing records for this species were found in the database.

In Iberian waters (VIIIc & IXa), at the stock level, there are very few correlations between the level of landings of hake and Nephrops and the rest of the species. Hake is only correlated with mackerel, the main contributor to landings (Table 16) and Nephrops is positive correlated with anglerfish (Table 17). Furthermore Nephrops landings present strong negative correlations with forkbeard, rays, squids and conger.

Table 16. Correlation between Hake landings and other species landings in Iberian waters.

MainSpecies	Bycatch	CorrCoef	LandMainSpecies	LandBycatch
HKE	MAC	0.83	9455	41547
	JAX	0.02		33057
	WHB	0.19		20516
	ANF	0.20		2618
	SQC	-0.20		1930
	LEZ	0.40		779
	RAJ	0.32		422
	NEP	-0.03		299
	COE	0.02		280
	SOL	0.38		221
	FOX	0.30		191

Table 17. Correlation between Nephrops landings and other species landings in Iberian waters.

MainSpecies	Bycatch	CorrCoef	LandMainSpecie:	LandBycatch
NEP	MAC	0.16	299	41547
	JAX	0.38		33057
	WHB	0.23		20516
	HKE	-0.03		9455
	ANF	0.61		2618
	SQC	-0.64		1930
	LEZ	0.49		779
	RAJ	-0.68		422
	COE	-0.60		280
	SOL	0.28		221
	FOX	-0.69		191

The same analysis was carried out by fishery. In this analysis the aggregation of data at the fishery level possibly masks the potential correlation between target and by-catch species. The assemblages at this level do not correspond with métiers assemblages where fleets actually operate. Additionally the data is aggregated by year, which blurs the effects of seasonality. Only the results of some representative cases are showed in the report.

When looking at the correlations between hake and the other species in the trawl fishery, hake has weak positive correlations with mackerel and megrims (Table 18). It should be noted that hake and mackerel are targeted by two different métiers of the trawl fleet.

Table 18. Correlation between Hake landings and other species landings in Trawl fishery in Iberian waters.

Fishery	MainSpecies	Bycatch	CorrCoef	LandMainSpecies	LandBycatch
Trawlers	HKE	WHB	0.25	5752	20224
		JAX	-0.09		16972
		MAC	0.56		15278
		SQI	-0.40		1627
		ANF	0.22		1495
		LEZ	0.52		764
		NEP	0.13		288
		RAJ	0.06		197

In the Bay of Biscay area (VIIIabde), at stock level, some correlations between hake, Nephrops and sole and the others were found. Hake correlates positively with seabass, megrims and blue whiting and negatively with cuttle fish, nephrops and red mullet (Table 19). Nephrops correlations are the opposite to hake ones, being positive correlated with red mullet, cuttlefish and squids (Table 20). Sole landings are correlated to sea bass and pollack, as it can be seen in Table 21.

Table 19. Correlation between Hake landings and other species landings in Bay of Biscay.

MainSpecies	Bycatch	CorrCoef	LandMainSpecies	LandBycatch
HKE	JAX	-0.18	6705	9970
	MAC	-0.58		8753
	ANF	-0.11		4446
	CTC	-0.90		3493
	SOL	0.38		3115
	NEP	-0.83		2525
	BSS	0.61		1142
	MUL	-0.86		1078
	RAJ	-0.81		1056
	SQC	-0.80		905
	WHG	0.66		885
	POL	-0.32		757
	LEZ	0.85		547
	WHB	0.74		176

Table 20. Correlation between Nephrops landings and other species landings in Bay of Biscay.

MainSpecies	Bycatch	CorrCoef	LandMainSpecies	LandBycatch
NEP	JAX	0.48	2525	9970
	MAC	0.59		8753
	HKE	-0.83		6705
	ANF	0.33		4446
	CTC	0.84		3493
	SOL	0.10		3115
	BSS	-0.22		1142
	MUL	0.97		1078
	RAJ	0.17		1056
	SQC	0.83		905
	WHG	-0.38		885
	POL	0.59		757
	LEZ	-0.60		547
	WHB	-0.73		176

Table 21. Correlation between Sole landings and other species landings in Bay of Biscay.

MainSpecies	Bycatch	CorrCoef	LandMainSpecies	LandBycatch
SOL	JAX	0.37		9970
	MAC	-0.34		8753
	HKE	0.38		6705
	ANF	0.34		4446
	CTC	-0.12		3493
	NEP	0.10		2525
	BSS	0.72		1142
	MUL	0.13		1078
	RAJ	0.01		1056
	SQC	0.05		905
	WHG	0.51		885
	POL	0.65		757
	LEZ	0.51		547
	WHB	0.18		176

As in the case of Iberian waters, at the fishery level the correlations cannot identify the real interactions between species because the aggregation level of data does not match with fleets' activities. As an example, the trawl fishery with Nephrops as main species shows a strong negative correlation with hake (Table 22). In fact it is known there are several métiers of trawl targeting different demersal species.

Table 22. Correlation between Nephrops landings and other species landings in Trawl fishery in Bay of Biscay.

Gears	MainSpecies	Bycatch	CorrCoef	LandMainSpecies	LandBycatch
Trawlers	NEP	ANF	0.46	2507	3415
		CTC	0.04		3108
		HKE	-0.72		2157
		SQU	0.25		1090
		RAJ	0.89		950
		MAC	-0.69		869
		SOL	0.47		812
		JAX	0.53		622
		MUX	0.62		607
		LEZ	-0.59		531
		PIL	-0.09		521
		WHG	0.03		463
		BSS	-0.23		352
		POL	0.89		208

Conversely, the analysis for the trammel net fishery in Bay of Biscay shows good correlations between sole and almost all of the by-catch species (Table 23).

Table 23. Correlation between Sole landings and other species landings in Trammel Net fishery in Bay of Biscay.

Fishery	MainSpecies	Bycatch	CorrCoef	LandMainSpecies	LandBycatch
TrammelNet	SOL	ANF	0.51	1749	391
		CTC	0.62		320
		BSS	0.81		260
		HKE	0.49		143
		POL	0.53		95
		RAJ	0.71		79
		WHG	0.93		66
		MUX	0.80		37
		MAC	0.21		12

In both areas, these results suggest that setting TACs individually for target species does not ensure conservation of the others species when global data by stock is analyzed. However, at the fishery level, different situations have been observed. A more detailed study per métier would allow detecting other important correlations.

Spatio-temporal allocation of effort by fleet and métier can modify correlations between species and tend to reconcile TAC.

9 ToR 3.5 – Multi-species TACs for by-catch stocks

A similar ToR was requested to the EWG 15 02, that evaluated the proposal of a MAP for the North Sea, and constituted the basis for the advice given by STECF (STECF, 2015). The EWG considered that the discussion and conclusions are still valid, and as such the text below is based on the work done by STECF (2015) with small edits.

In practice, grouping stocks already occurs in other areas. For example, in the North Sea there are grouped TACs for turbot and brill, for flounder and dab, and for lemon sole and witch flounder. Likewise, skates and rays are currently managed under a grouped TAC. The status for these stocks is generally estimated separately for the individual stocks, using one of the Data Limited Stock methodologies in ICES. Often, this means the stock status is assessed using survey trends.

In theory, the considerations on the sustainability of combined TACs are similar if several species are combined, or if several stocks of the same species are combined. In the North Sea, several stocks of *Nephrops* are combined into a single TAC. Examples of grouping TACs can also be seen in other areas. In the Northeast Atlantic for example, there are grouped species TACs for monkfish and megrim: the two species of monkfish sharing a single TAC, and two species of megrim sharing a single TAC.

One of the problems with addressing this ToR is the use of the term “by-catch”, without specifying exactly what it entails. There are many different definitions of “bycatch”. In the description of advantages and disadvantages of grouping quota that is given below, “bycatch” is defined as catches that are caught unintentionally while catching target species and target sizes. Bycatch can either be of a different species, or the undersized or juvenile individuals of the target species. However, what is a target species and what is a bycatch species depends on the fishery, and different vessels within a fleet may have different target species and bycatches. If combined TACs for so-called bycatch species are introduced, there will be a need to precisely define which species constitute the bycatch and this may need to be specified separately for different fisheries.

One of the **advantages** of combined TACs is that it provides increased flexibility for fishers to deal with the variability in bycatches. Hence catches within a quota can be substituted, so the species that potentially choke a fishery can be substituted by other species thereby allowing fishing on the target species to continue. Such increased flexibility could also improve the reporting of catches taken under the bycatch quota, because there would be less of an incentive to under- or mis-report the by catch species.

Furthermore, setting individual quotas for species that have until now been largely discarded is surrounded with a high level of uncertainty. Combining stocks may alleviate the problems with setting quota for such species individually, and create a buffer against uncertainty in the assessment and management of such stocks.

One of the **disadvantages**, by definition, is that combined TACs do not necessarily constrain the catches of individual species, because substitution between species subject to the combined TAC may take place. This could lead to overexploitation of some species, especially when combining vulnerable and invulnerable species.

The amount of substitution depends on several factors:

- the species composition and relative weight of those species in the bycatch: a large difference in the catch weights allows for easy substitution of a relatively large part of a small catch with a relatively small part of a large catch.
- the differences in net economic benefit (depending on price, and costs of exploitation) of the different bycatch species: a large difference in net economic benefit will generate an incentive to substitute lower value species with higher value species.

While one of the potential benefits of combined quotas is a reduction in the underreporting of catches, in the long run there is a risk of mislabelling of catches for pooled species that have a similar appearance and market price. This has previously been observed with anglerfish, skates and rays.

As mentioned above, to introduce combined TACs for bycatches, the terms “bycatch” and “target” need to be clearly defined, perhaps on a fishery or fleet basis. If vulnerability to overfishing of the bycatch species that comprise the combined TAC is considered a flexible system in which the grouping is regularly evaluated. The costs of monitoring and managing such a system are likely to be high.

In order to mitigate the above disadvantages, the species composition of mixed-species TACs would need to be tracked to monitor the changes in the catchability and the vulnerability of the bycatch species to overfishing.

Combining species of different vulnerabilities that have large differences in price, and large differences in catch volumes should be avoided. There are a range of sources available for this information. For example, information on vulnerability indices by species (from Cheung et al. 2005, based on life history parameters) can be extracted from FishBase; prices can be found in the STECF Annual Economic report database; data on stock and catch status can be extracted from the STECF Consolidated Review of Advice and from ICES.

Finally, under a precautionary approach the combined-species TACs could be set lower than the sum of the individual species TACs to account for the increased risk of overexploitation of the individual species, due to the uncertainty associated with the conservation of the species grouped in a single TAC.

10 CONCLUSIONS

10.1 ToR 3.1-3.3

- Simultaneously managing a number of stocks at single species F_{MSY} levels is likely to fail and create inconsistencies between targets for different stocks.
- In the context of mixed fisheries, fishing opportunities can more easily be reconcile and made consistent with achieving the objectives of the CFP, using the flexibility provided by the F_{MSY} ranges.
- Adopting F_{MSY} ranges may increase the risk of overfishing if a decision is taken to persistently fish at the upper limits of the ranges. Taking into account the mixed fisheries constrains on matching the single species targets simultaneously, the benefits in terms of flexibility and adaptability would be lost, the probability of some stocks falling below B_{pa}/B_{lim} reference points may increase and the economic performance could be impacted negatively.
- Fishing at lower limits of the Fmsy ranges generate larger SSB, lower catches and require less effort by fleet when compared with the baseline. The opposite pattern is observed when fishing at the upper limit of the Fmsy ranges.
- The fleets that are responsible for most of the employment in this area don't seem to be very dependent on the species that will be regulated through this MAP.
- Biomass safeguards for all stocks should still be maintained and should provide a basic level of protection.
- Inter-annual catch constraints should be kept to stabilize inter-annual fishing opportunities.
- The scientific advisory process will have to be more focus on mixed fisheries.
- Sole safeguard and F reference point is likely to be reviewed by ICES.
- Horse mackerel is not achieving the F target and the safeguard is operating ~10% of the times, which may be an indication of inconsistencies in reference points.
- The evaluation of the Management Plan proposal provides a general comparison of the expected outcomes of managing the stocks using a MAP when compared with the basic provisions of the CFP.

- Knowledge about the mixed fisheries system is still partial and does not allow a full evaluation of the risks associated with all management options.
- Due to time constraints the models were not updated to incorporate all fleets and stocks that exist on the SWW.
- Not having an HCR introduces an extra level of uncertainty on future decisions. For the EWG work it represented a limitation on the capacity to simulate and evaluate the plan.
- The impact of the LO cannot be evaluated at this time due to the limited time available and the uncertainty associated with the implementation of the measures.

10.2 ToR 3.4

- The number and scope of MAPs is largely a policy decision. If the implementation is correct then the number and scope of the MAPs shouldn't impaired the achievement of the CFP objectives.
- Having larger MAPs may “promote” more coherent regulations in terms of objectives and safeguards for each stock and avoid over-regulating the sector.
- Having smaller MAPs increases the potential of over-regulating the sector but may promote more localized management measures and contribute to the involvement of stakeholders.

10.3 ToR 3.5

- Catch control measures over the species that drive the fisheries are not likely to drive the exploitation of non-driver species and as such will not guarantee the levels of conservation required by the CFP. Dynamics regarding the target species seem to occur at the fleet level.
- Grouping a number of single species TACs could introduce additional flexibility in the management of this system. However, the trade-off is that the potential to overexploit some stocks appears to increase. A set of mitigation principles were identified which should be considered if grouping of single species TACs is finally included in a management plan. Intense and strict monitoring will be essential to ensure that non-target species, or those less easily identified, are not overfished. The inclusion of fishing effort controls should also be considered in this case.

11 CONTACT DETAILS OF STECF MEMBERS AND EWG-15-04 & EWG-015-09 PARTICIPANTS

Information on STECF members and invited experts' affiliations is displayed for information only. In some instances the details given below for STECF members may differ from that provided in Commission COMMISSION DECISION of 27 October 2010 on the appointment of members of the STECF (2010/C 292/04) as some members' employment details may have changed or have been subject to organisational changes in their main place of employment. In any case, as outlined in Article 13 of the Commission Decision (2005/629/EU and 2010/74/EU) on STECF, Members of the STECF, invited experts, and JRC experts shall act independently of Member States or stakeholders. In the context of the STECF work, the committee members and other experts do not represent the institutions/bodies they are affiliated to in their daily jobs. STECF members and invited experts make declarations of commitment (yearly for STECF members) to act independently in the public interest of the European Union. STECF members and experts also declare at each meeting of the STECF and of its Expert Working Groups any specific interest which might be considered prejudicial to their independence in relation to specific items on the agenda. These declarations are displayed on the public meeting's website if experts explicitly authorized the JRC to do so in accordance with EU legislation on the protection of personnel data. For more information: http://stecf.jrc.ec.europa.eu/adm-declarations

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12 List of Background Documents

Background documents are published on the meetings websites on:
http://stecf.jrc.ec.europa.eu/web/stecf/ewg1504 and http://stecf.jrc.ec.europa.eu/web/stecf/ewg1509

List of background documents:

1. EWG-15-04 / 09 - Declarations of invited and JRC experts (see also section 11 of this report – List of participants)

13 LIST OF ELECTRONIC ANNEXES

Electronic annexes are published on the meeting's web site on:
http://stecf.jrc.ec.europa.eu/web/stecf/ewg1504 and http://stecf.jrc.ec.europa.eu/web/stecf/ewg1509

List of electronic annexes:

2. Annex I - Bio-economic impact assessment of multiannual management plans (MAPs) for the Spanish demersal fishing fleets in the Bay of Biscay
3. Annex II - Bio-economic impact assessment of multiannual management plans (MAPs) for Iberian demersal mixed fisheries
4. Annex III - Bio-economic Impact Assessment of the multi-annual management plan (MAP) for the Celtic Sea (ICES divisions VII bc, e-k) fisheries
5. Annex IV - IAM Description
6. Annex V - F ranges and Fleet Behaviour
7. Annex VI - Documents on FMSY ranges
    a. WD1: Review of proxies for Fmsy ranges for Iberian Peninsula stocks (Southern hake, megrims and white anglerfish)
    b. MSY reference points for haddock in VIIbce-k Working document to WGCSE 2015
    c. Proxies for FMSY ranges using predictive linear models
8. Annex VII - Dependency and employment for the most dependent fleets. Dependency of North Western Atlantic waters (area 27.6 & 27.7) fleets on target demersal species
9. Annex VIII – Employment and degree of dependency by fleet

14 ANNEX I – CODES AND ACRONYMS

14.1 COUNTRIES CODES

Alpha 3 code	*Other codes used*	*Contry name*
BEL	Be	Belgium
FRA	Fr	France
GBR	Gb	United Kingdom
	En	*England*
	Sc	*Scotland*
NLD	Nl	Netherlands
ESP	Es	Spain
IRL	Ir	Ireland
PRT	Pt	Portugal

14.2 SPECIES CODES

Anf	Anglerfishes nei
Cod	Cod
Had	Haddock
Hal	Halibut
Her	Herring
Hke	Hake
Jax	Jack and horse mackerels nei
Mac	Mackerel
Nep	Nephrops
Nop	Nethrops
Ple	Plaice
Pok	Saithe(=Pollock)
San	Sandeels
Shr	Shrimps
Sol	Sole
Whg	Whiting

14.3 IAM FLEET CODES

Fleet label	Definition
HKE GN VL1840	Hake gillnetters VL 18-40 m

HKE LL VL0010	Hake longliners VL <10 m
HKE LL VL1012	Hake longliners VL 10-12 m
MBT NBoB VL1218	Mixed bottom trawlers North Bay Biscay VL 12-18 m
MBT NBoB VL1824	Mixed bottom trawlers North Bay Biscay VL 18-24 m
MBT SBoB VL1218	Mixed bottom trawlers South Bay Biscay VL 12-18 m
MBT SBoB VL1824	Mixed bottom trawlers South Bay Biscay VL 18-24 m
MCBT VL0010	Mixed coastal bottom trawlers VL <10 m
MCBT VL1012	Mixed coastal bottom trawlers VL 10-12 m
Mix NET VL0010	Mixed netters VL <10 m
Mix NET VL1018	Mixed netters VL 10-18 m
Mix NET VL1840	Mixed netters VL 18-40 m
NEP BT SP VL0012	Nephrops bottom trawlers (specialized) VL <12 m
NEP BT SP VL1224	Nephrops bottom trawlers (specialized) VL 12-24 m
NEP BT USP VL0012	Nephrops bottom trawlers (unspecialized) VL <12 m
NEP BT USP VL1218	Nephrops bottom trawlers (unspecialized) VL 12-18 m
NEP BT USP VL1824	Nephrops bottom trawlers (unspecialized) VL 18-24 m
SOL NET VL0010	Sole nettersVL <10 m
SOL NET VL1012	Sole nettersVL 10-12 m
SOL NET VL1218	Sole nettersVL 12-18 m
SOL NET VL1824	Sole nettersVL 18-24 m

Labels and definitions of French fleets included in the IAM analysis of the Bay of Biscay sole and nephrops fisheries. VL=vessel length.

14.4 DCF AND RELATED CODES

FISHING_TECHNIQUE

DFN	Drift and/or fixed netters
DRB	Dredgers
DTS	Demersal trawlers and/or demersal seiners
FPO	Vessels using pots and/or traps
HOK	Vessels using hooks
MGO	Vessel using other active gears
MGP	Vessels using polyvalent active gears only
PG	Vessels using passive gears only for vessels < 12m
PGO	Vessels using other passive gears
PGP	Vessels using polyvalent passive gears only

PMP	Vessels using active and passive gears
PS	Purse seiners
TM	Pelagic trawlers
TBB	Beam trawlers

VESSEL_LENGTH classes

VL0010	Vessel between 0 meters and 10 meters in length.
VL1012	Vessel between 10 meters and 12 meters in length.
VL1218	Vessel between 12 meters and 18 meters in length.
VL1824	Vessel between 18 meters and 24 meters in length.
VL2440	Vessel between 24 meters and 40 meters in length.
VL40XX	Vessel greater than 40 meters in length.
o10m	Over 10 meters
u10m	Under 10 meters

FISHING GEAR

DRB	Boat dredges
DRH	Hand dredges
FPN	Stationary uncovered pound nets
FPO	Pots
FYK	Fyke nets
GNC	Encircling gillnets
GND	Driftnets
GNS	Set gillnets (anchored)
GTN	Combined gillnets-trammel nets
GTR	Trammel nets
HMD	Mechanised dredges including suction dredges
LA	Lampara nets
LHM	Handlines and pole-lines (mechanised)
LHP	Handlines and pole-lines (hand-operated)
LLD	Drifting longlines
LLS	Set longlines

LNB	Boat-operated lift nets
LNS	Shore-operated stationary lift nets
LTL	Troll lines
MIS	Miscellaneous Gear
NK	NOT KNOWN*
NO	NO GEAR
OTB	Bottom otter trawl
OTM	Midwater otter trawl
OTT	Otter twin trawl
PS	Purse seines
PTB	Bottom pair trawl
PTM	Pelagic pair trawl
SB	Beach seines
SDN	Danish seines
SPR	Pair seines
SSC	Scottish seines
SV	Beach and boat seines
TBB	Beam trawl

14.5 ACRONYMS

AER – Annual economic report
CFP - Common Fisheries Policy
ICES - International Council for the Exploration of the Sea
MSY – Maximum sustainable yield
CPUE – Catch per unit of effort
TAC – Total Allowable Catch
TAL – Total Allowable Landings
STECF - Scientific, Technical and Economic Committee for Fisheries
SG-MOS – Sub-group on management objectives and strategies
BoB – Bay of Biscay
NWW – North Western Waters
SWW – South Western Waters

HCR – Harvest Control Rules

MAP – Multi-annual plan

EwE - Ecopath with Ecosim model

LO - Landings obligation

FTE - Full Time Equivalent

FMSY – fishing mortality that provides maximum sustainable yield

SSB – Spawning stock biomass

HCR – Harvest Control Rule

European Commission

EUR 27406 EN – Joint Research Centre – Institute for the Protection and Security of the Citizen
Title: Scientific, Technical and Economic Committee for Fisheries. Multiannual management plans SWW and NWW (STECF-15-08).

Authors:

STECF members:
Graham, N., J., Abella, J. A., Andersen, J., Bailey, N., Bertignac, M., Cardinale, M., Curtis, H., Daskalov, G., Delaney, A., Döring, R., Garcia Rodriguez, M., Gascuel, D., Gustavsson, T., Jennings, S., Kenny, A., Kraak, S., Kuikka, S., Malvarosa, L., Martin, P., Murua, H., Nord, J., Nowakowski, P., Prellezo, R., Sala, A., Scarcella, G., Somarakis, S., Stransky, C., Theret, F., Ulrich, C., Vanhee, W. & Van Oostenbrugge, H.

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STECF

The Scientific, Technical and Economic Committee for Fisheries (STECF) has been established by the European Commission. The STECF is being consulted at regular intervals on matters pertaining to the conservation and management of living aquatic resources, including biological, economic, environmental, social and technical considerations.

JRC Mission

As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

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NORTH-WESTERN MEDITERRANEAN WATERS

General description

Although low primary production in the Mediterranean determines that fisheries are not of great importance from the point of view of catches, fishing has a long tradition, which combined with the diversity of habitats has led to the variety of fisheries that we can currently observe. Moreover, although the amount of catches is relatively moderate compared to other marine areas of high productivity, the fact that the Mediterranean coast is an area of great tourist importance means that, in general, the commercial value of the species caught be high.

For example, the total landings, accounting for all species in the GSA 6 show a decreasing trend in the period studied (1998-2013). Starting from a peak of nearly 100 000 t in 2000, slowly decreasing to 63 000 t in 2013, with an average of 75 000 t in the considered period.

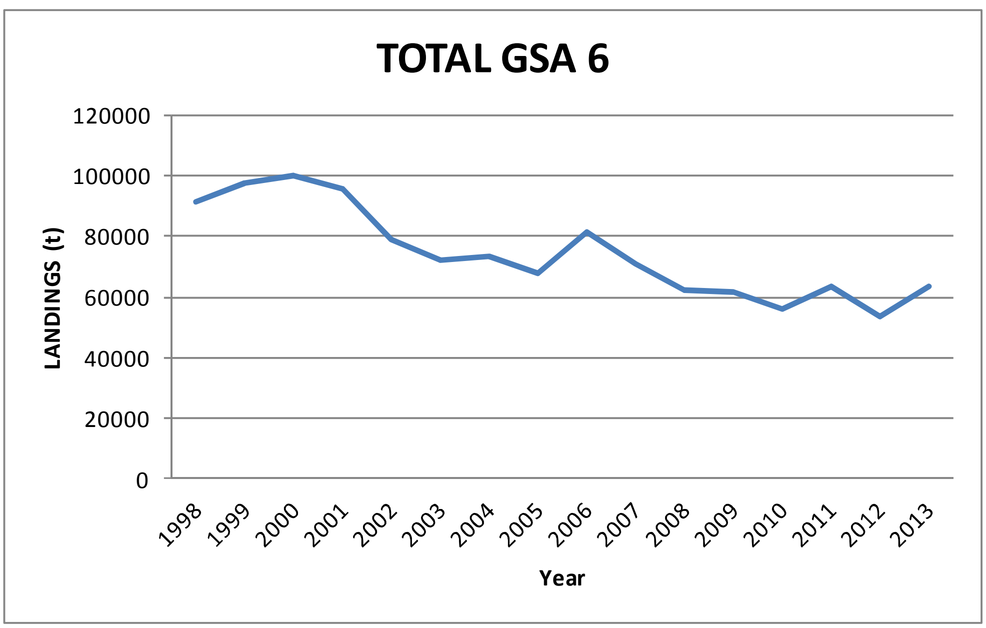


Figure 1.1 Total landings evolution in GSA 6 in the period comprised between 1998 and 2013.

Moreover, despite the decline in landings, economic volume generated by them at first auction shows greater stability in the same period, with an average total value of 221 million Euros per year.

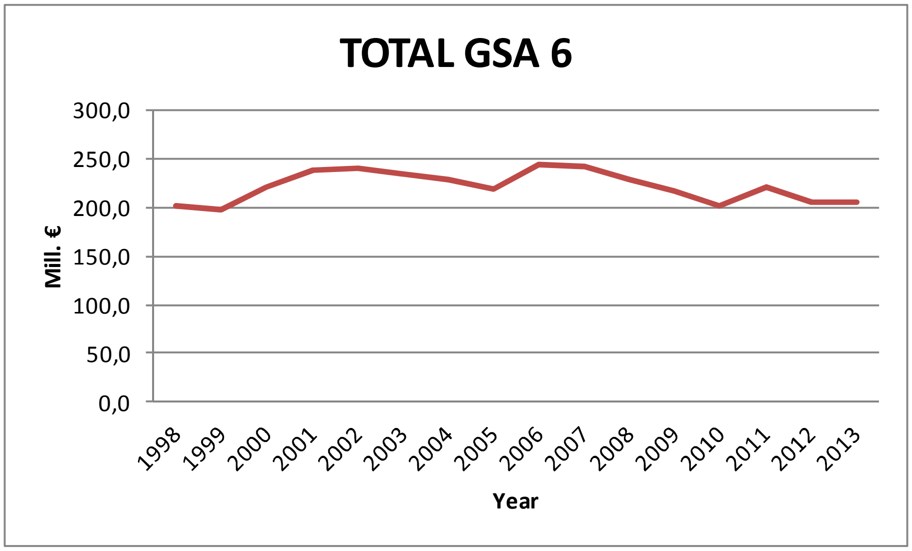


Figure 1.2 Evolution of total value of landings in GSA 6 in the period comprised between 1998 and 2013.

Species composition

In the case of pelagic fisheries target species are sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*). In the case of demersal trawl fisheries, hake (*Merluccius merluccius*), red mullet (*Mullus spp*), white shrimp (*Parapenaeus longirostris*), red shrimp (*Aristeus antennatus*), Norway lobster (*Nephrops norvegicus*), the octopus (*Octopus vulgaris*) and anglerfish (*Lophius spp.*) are the target species.

Benthic and demersal species are exploited by the semi-industrial trawler fleets as well as artisanal vessels. Artisanal fisheries are characterized by high diversity of species caught and by the absence of large monospecific stocks. Although the number of artisanal vessels is important in some areas with high social impact, catches account for only a very small part of the total. Overall, artisanal fishing is characterized by the diversity of fishing gears and caught species, the high market value thereof, almost no incidence of discards and the form of exploitation of resources, more selective and adapted to the seasonal changes of abundance The dominant gears are fishing gillnets (trammel nets) and entangle nets (monofilament nets). There are several varieties of trammel according to the target species as the common octopus (*Octopus vulgaris*), cuttlefish (*Sepia officinalis*), red mullet (*Mullus spp*.) or different species of sea bream.

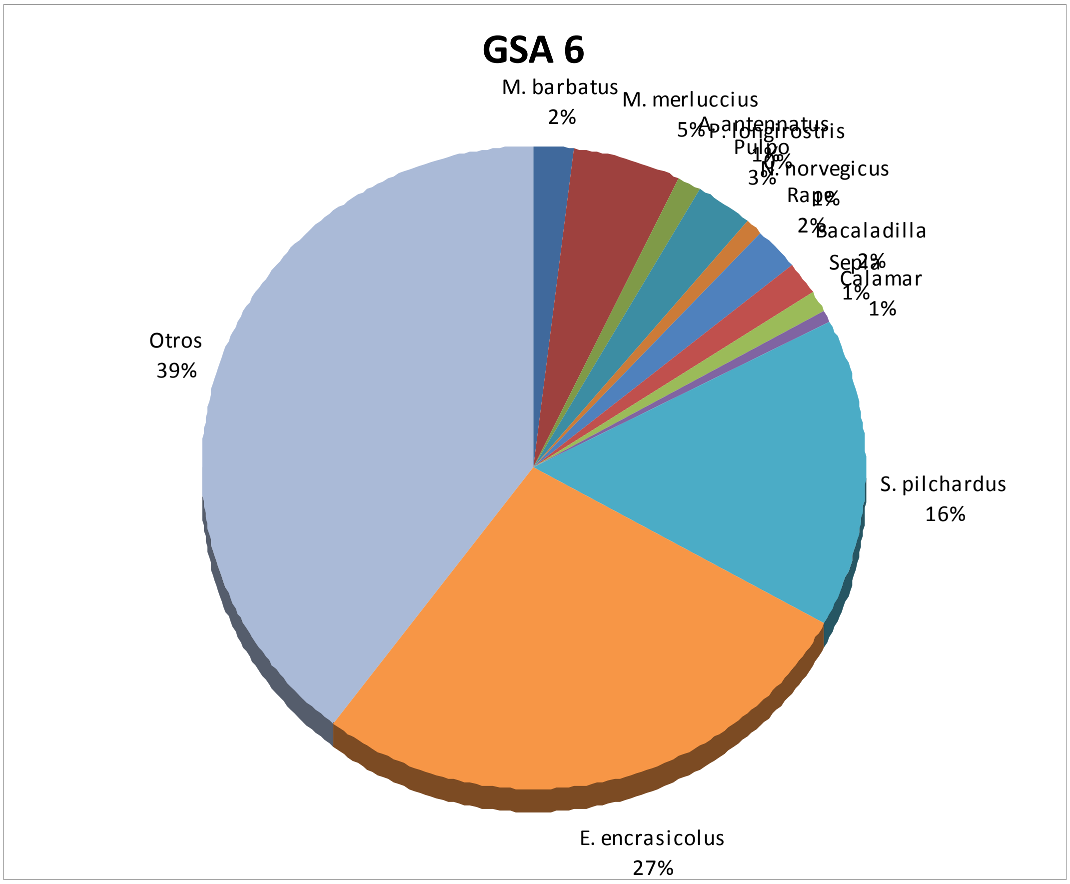


Figure 1.3. Species contribution to the total landings in GSA 6, observed in 2013.

The main species are anchovy and sardine. Other small pelagic species, with lower economical value are also landed, but rarely they are target species and almost always represent a rather low percentage of the total landings: the Mediterranean mackerel and the horse mackerels (*Trachurus mediterraneus* and *T. trachurus*), the mackerel and the chub mackerel (*Scomber scombrus* and *S. japonicus*), and the gilt sardine (*Sardinella aurita*) are the most important ones.

Most of the landings of demersal species come from the bottom trawl fleets. The multispecies nature of the bottom trawl fishery is evident if we consider that catches can eventually identify more than 600 species from different taxonomic groups. Consequently, the proportion of discards is very high, up to 77% of species and 30-40% of the total weight caught. The exploitation extends to both the platform and the continental slope; the predominant species at landings vary with depth.

In the case of demersal species the fleet segmentation consists of three metiers:

1. Mixed Demersal species (typically vessels 6-18 meters), with a value of landings in 2009 of €33 million, with a net profit per vessel around €25.000. The employment on board was 642 FTE.

2. Mixed Demersal and red shrimps species, both taking place on the shelf and shelf break (typically vessels 18-24 meters and operating in the upper slope of continental shelf), the value of landings in 2009 was €97 million, with a net profit per vessel around €15.000. The employment on board was 1975 FTE in 2009.

3. Red shrimp fisheries operated on the slope up to 400 m depth (length category 24-40m). The value of landings in 2009 was €65 million, yielding significant losses. The employment on board was 987 FTE in 2009.

The Principal target species for the “Mixed Demersal” and “Mixed Demersal and red shrimps” fleet segments are Red mullets (*Mullus surmuletus, M. barbatus*); Octopus (*Octopus vulgaris*) Horse mackerels (*Trachurus trachurus*, *T. mediterraneus*); European hake (*Merluccius merluccius*); Monkfish (*Lophius piscatorius*) Anglerfish (*L. budegassa*); White shrimp (*Parapenaeus longirostris*) and Norway lobster, (*Nephrops norvegicus*). While for the “red shrimps” fleet segment the target species is the red shrimp (*Aristeus antennatus*).

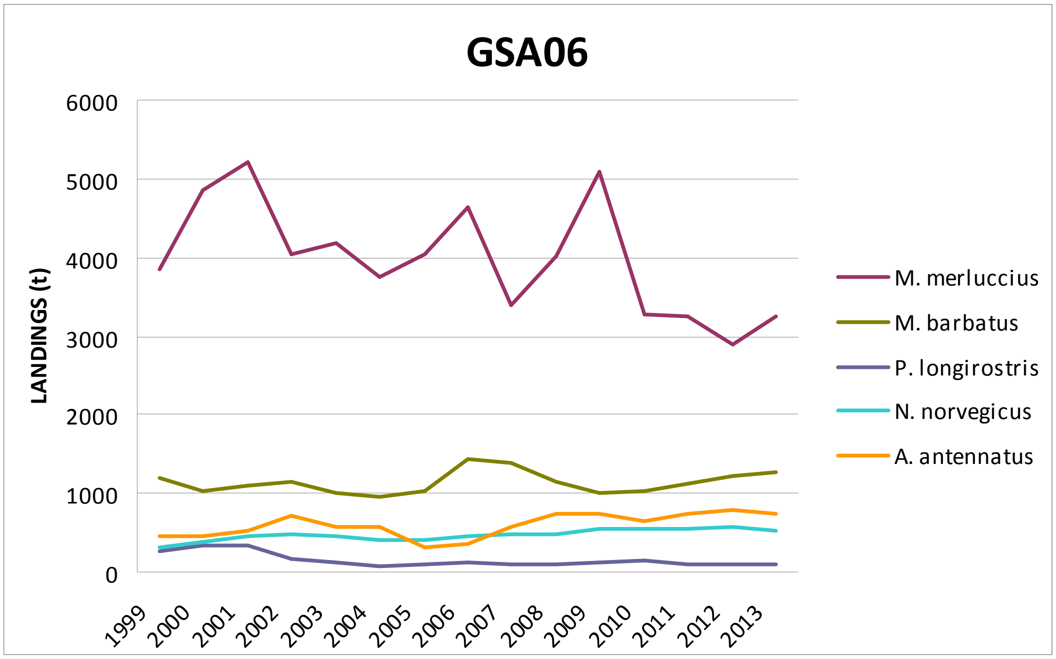


Figure 1.4. Evolution of landings of the main demersal species in GSA 6 in the period comprised between 1999 and 2013.

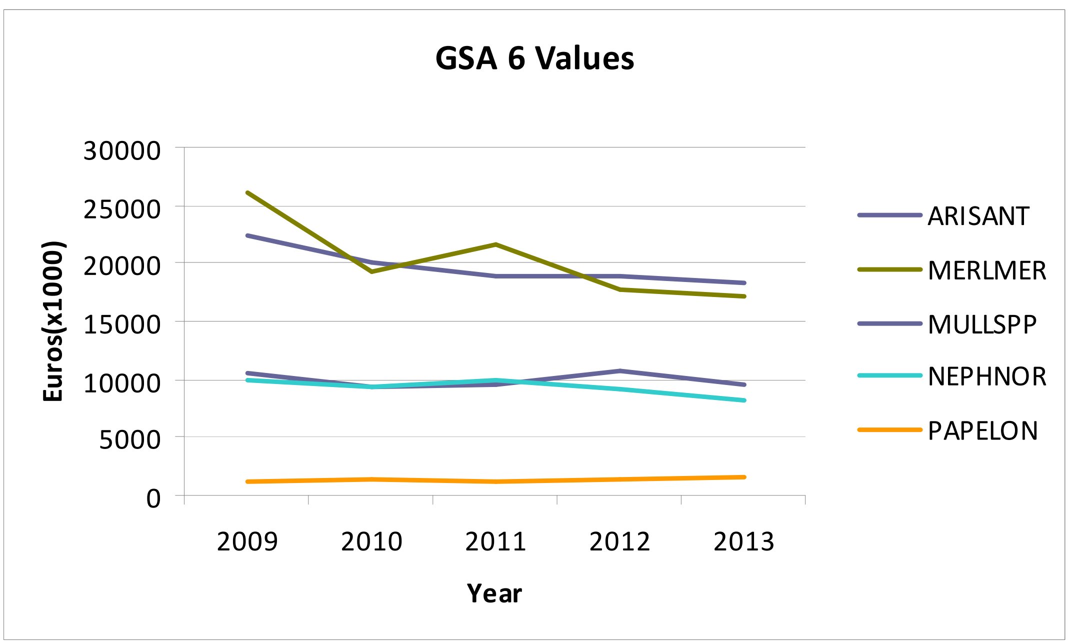


Figure 1.5. Evolution of economic value of the main demersal species in GSA 6 in the period comprised between 2009 and 2013.

Economically, the red shrimp is the most important species in the trawl fishery, contributing between 30 and 50% of the total incomes for the trawl fleet. However the contribution in weight is lower, between 5 and 20% depending on the area.

Fishery

The trawl fleet previously undertook daily trips, although some vessels are able to undertake trips lasting between two and four days. The number of hauls in a single daily trip is between 1 and 5. In average the number of sea days by boat is between 100 and 190 days, but typically around 140-160 days.

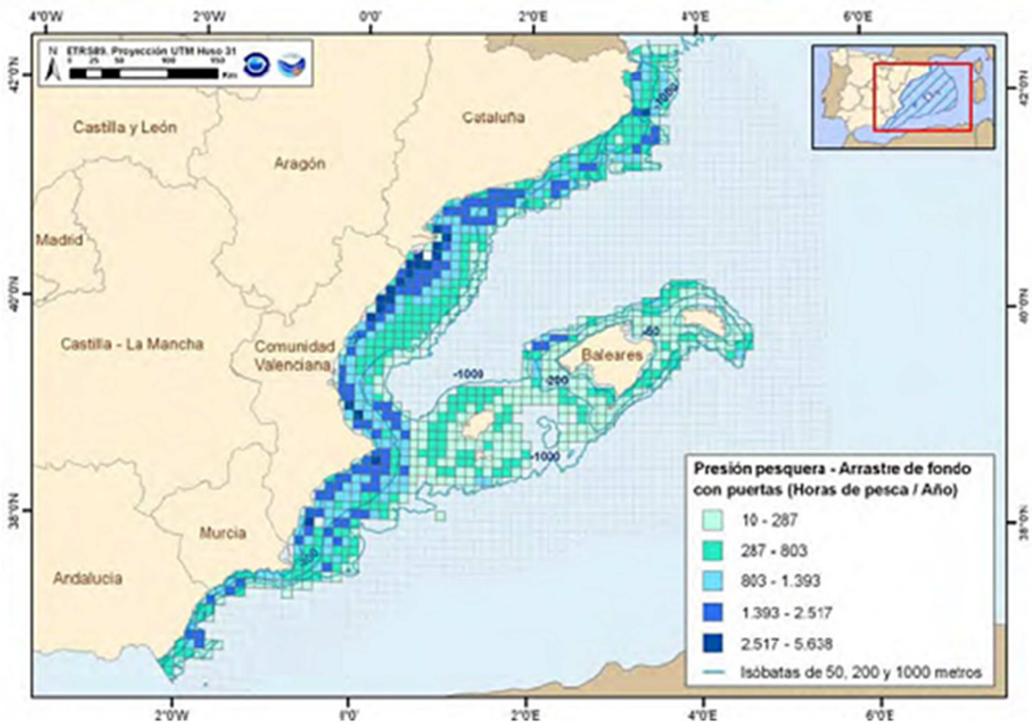


Figure 1.6. Spatial distribution of the cumulated effort (total hours by year) for the OTB fleet in GSA 6.

Discard rates for target species such as red shrimp, white shrimp, mullets and octopus are very low, typically less than 10% for fish species and lower for the two shrimp species (<2%). One species of the group of octopuses *(Eledone moschata*) have been one high sporadic discard. Discards of mullet and red mullet in Spanish Mediterranean waters are quite inexistent due to their high market value.

The Gulf of Lions supports fisheries that include bottom and pelagic trawls, purse seines, gill nets and longlines, and is furthermore an important spawning area for many pelagic and demersal species. The demersal fisheries are multi-species and multi-gears fisheries. The marine living resources of the Gulf of Lions are a “shared stock” which is essentially exploited by French and Spanish fishing boats. The main part of the fishing grounds exploited by these boats cover the entire continental shelf from the coastline to the 200 metres isobath, with an area of some 14 000 square kilometres covered by sandy deposits. This particular geomorphology has been conducive to the development of trawling there. Off the French coasts, the Spanish fishing activity was confined at first in a restricted zone included between 6 and 12 miles, from the French-Spanish border up to Cap Leucate (the so called "zone of the border treaty" 1967-68). At the beginning of the 80s this activity extended offshore and to the east of the continental shelf.

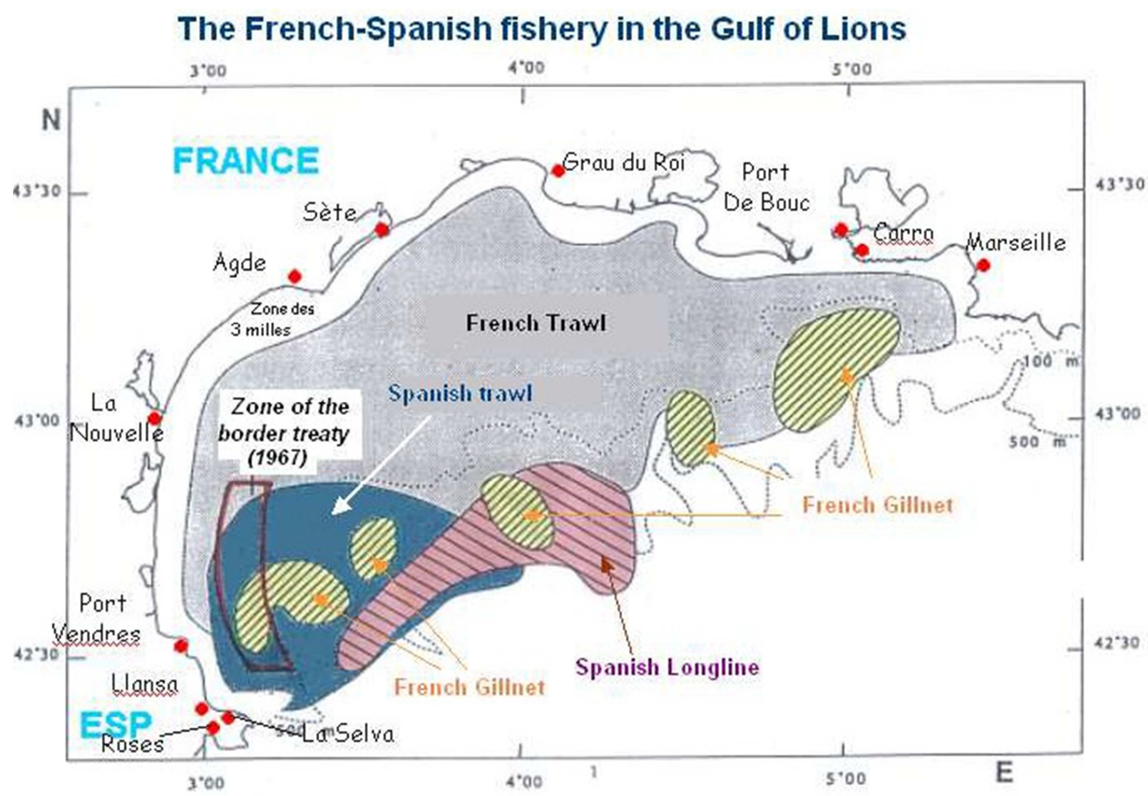


Fig.1.7- The fishing sectors of the various components of the French-Spanish fleet

The fleet

The fishing activities (métiers) considered for reporting catch and effort data in the GSA 06 are shown in the following table:

Gear Group	Metier	Target species
Bottom otter trawl	OTB-DES	Demersal species
	OTB-DWS	Deep water species
	OTB-MDD	Mixed demersal and deep water species
Trammel nets	GTR-DES	Demersal species
Pots and Traps	FPO	Demersal species
Surrounding nets	PS-SPF. Purse seine	Small pelagic species
	PS-LPF. Purse seine	Large pelagic species
Longlines	LLD. Drifting longline	Large pelagic species
	LLS. Set longline	Demersal species

According to the more recent data of the Spanish Ministry Fleet register, the total fleet in the GSA06 accounts for a total of 1313 vessels. The fleet is composed mainly by artisanal vessels between 6 and 12 m of Overall length (LOA), and trawlers between 18 and 24 m of Overall length (Table 1.2.1).

Table 1.2. GSA06 Mediterranean fleet. Source of data: Spanish Ministry fleet register (January 2015)

	Vessel Length	Nº vessels	Average GT	Average LOA	Average Kw
Artisanal fleet	VL<06	57	0.96	5.36	13.23
	VL0612	533	3.78	8.79	52.38
	VL1218	97	11.10	13.23	95.27
	VL1824	-	-	-	-
	VL2440	2	197.75	27.00	570.00
	Total	**689**	**5.14**	**9.18**	**56.88**
Otter bottom trawl	VL0612	15	8.35	10.33	47.20
	VL1218	111	24.15	15.56	99.11
	VL1824	215	58.95	21.10	262.05
	VL2440	107	99.28	25.54	430.43
	Total	**448**	**58.27**	**20.43**	**254.70**
Purse seine	VL0612	3	5.97	10.64	87.00
	VL1218	36	27.12	16.25	236.78
	VL1824	59	46.26	20.78	307.04
	VL2440	20	76.07	25.20	379.70
	Total	**118**	**44.45**	**19.89**	**292.33**
Purse seine (BFT)	VL2440	4	228.19	36.31	1175.75
	VL>40	2	349.80	43.43	1622.00
	Total	**6**	**268.73**	**38.68**	**1324.50**
Set longline	VL0612	21	4.29	9.01	75.05
	VL1218	10	14.39	13.29	140.50
	VL1824	1	33.69	18.00	270.00
	Total	**32**	**8.36**	**10.63**	**101.60**
Drifting longline	VL1218	16	14.95	13.97	89.12

	VL1824	4	47.76	19.40	225.75
	Total	**20**	**21.51**	**15.06**	**116.45**
TOTAL		**1313**	**28.33**	**14.24**	**153.62**

The number of vessels in this area has been continuously decreasing in the last decade, from more than 2080 vessels in 2004 to 1313 in 2015. The biggest reductions have taken place in the set longliners, the artisanal fleet and the bottom trawlers. Also the purse seine fleet has been continuously decreasing, from 164 vessels in 2004 to 118 in 2015. The number of drifting longliners and the purse seine for bluefin tuna is constant in this years (Figure 1.2.1).

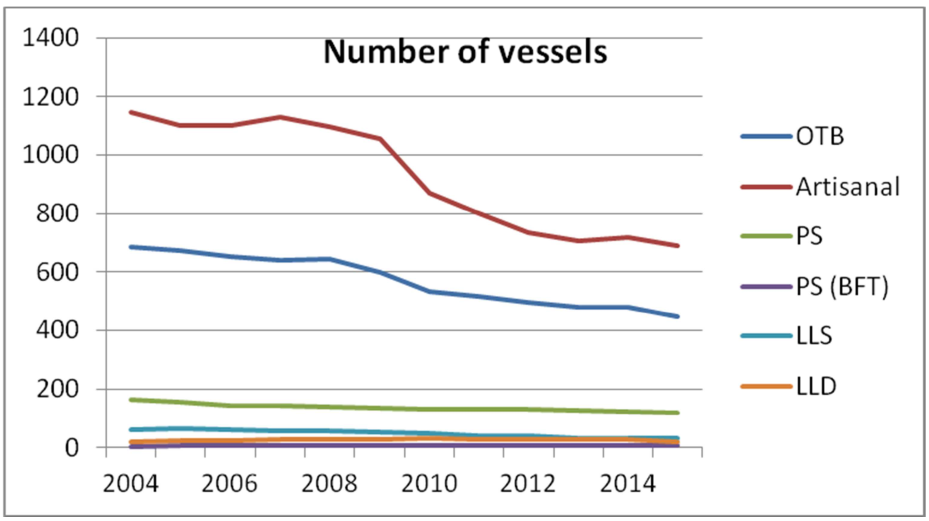


Figure 1.8. Evolution of the number of vessels in the GSA06. OTB: Bottom otter trawl; Artisanal: artisanal fleet; PS: purse seine; PS (BFT): purse seine for bluefin tuna; LLS: set longline; LLD: drifting longline.

The fleet is distributed in 54 ports along the coast, while 28 of them have less than 15 operative vessels. As concerns the number of vessels, the main harbours in the GSA06 are San Carlos de la Rápita, Santa Pola, Vilanova I la Gertrú, San Pedro del Pinatar, Ametlla de Mar and Blanes (Tab. 1.2.2).

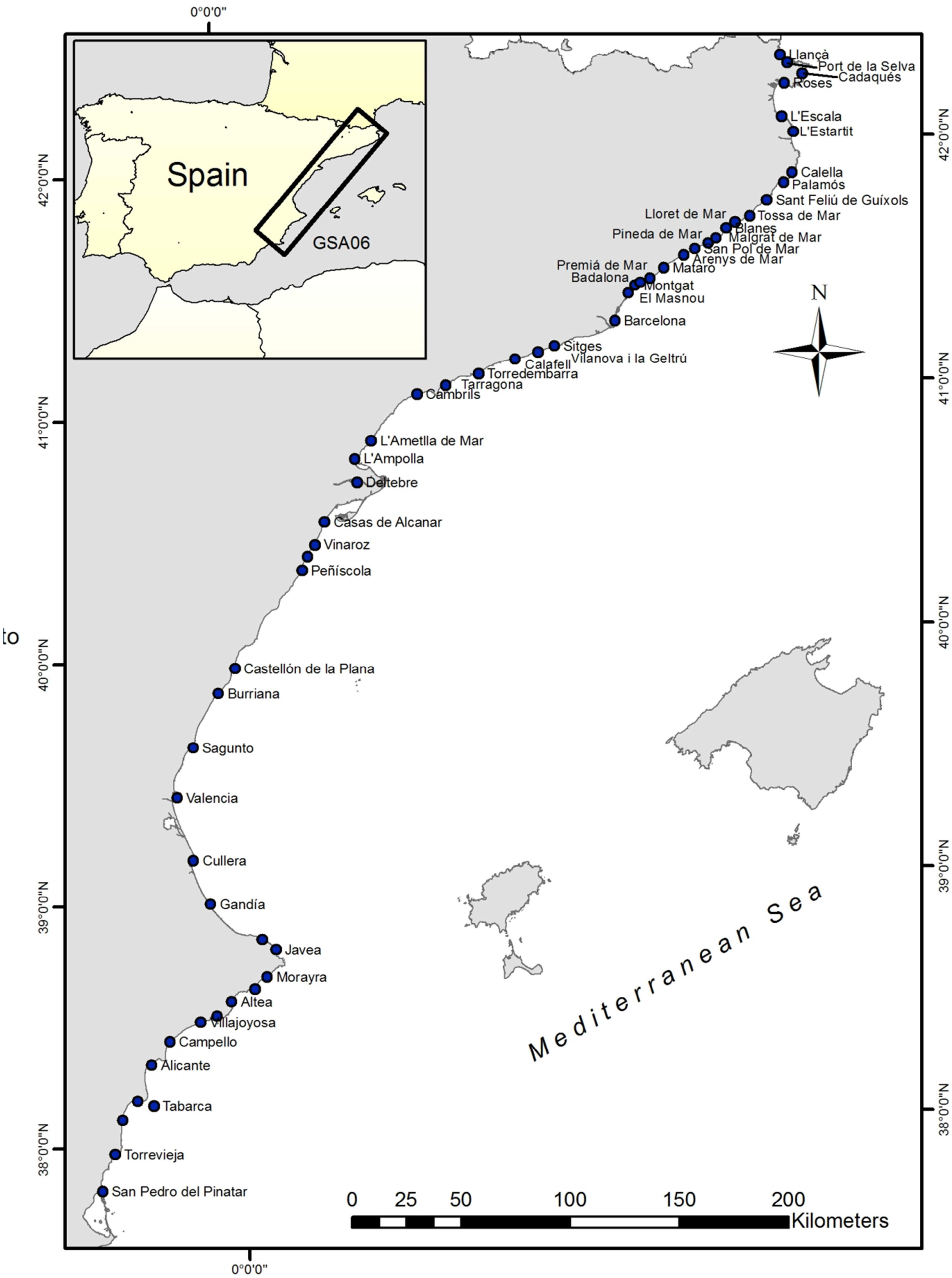


Figure 1.9 – Fishing ports location along the GSA 6 coast.

Table 1.3. - Ports and number of vessels by fleet. Source of data: Spanish Ministry fleet register (January 2015)

Port	Artisanal	OTB	PS	PS (BFT)	LLS	LLD	Total
Altea	5	10	2				17
Ametlla de Mar	19	21	7	6	1	1	55
Arenys de Mar	31	14	7			1	53
Barcelona	1	13	21				35
Benicarló	10	19					29
Blanes	22	18	6		4	4	54
Burriana	17	7	5			1	30
Calpe	5	15					20
Cambrils	9	17	4				30
Castellón	16	16	14			3	49
Cullera	33	14			2		49
Denia	13	17	1			2	33
Gandía	40	6					46
Jávea	8	6	4				18
La Escala	14		6		2		22
Palamós	14	25	4		5	1	49
Peníscola	14	25			1		40
Roses	23	19	6		4		52
San Carlos de la Rápita	41	46					87
San Pedro del Pinatar	54	1	1				56
Santa Pola	51	29					80

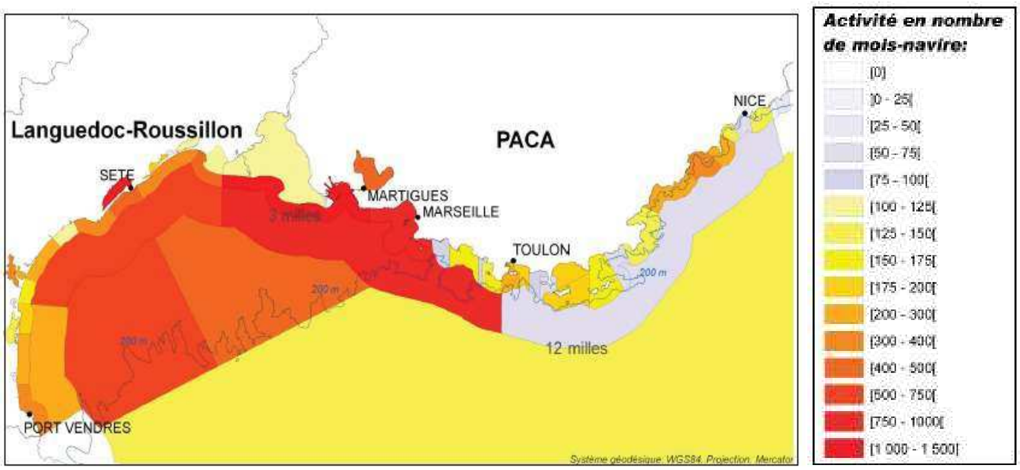
Tarragona	10	31	9		1	1	52
Valencia	13	5					18
Vilanova i la Geltru	30	22	9		7	3	71
Villajoyosa	11	29					40
Vinaroz	19	10	3				32
Others (28 minor ports)	166	13	9		5	3	196
TOTAL	**689**	**448**	**118**		**32**	**20**	**1313**

The boats exploiting the marine resources of the Gulf of Lions (GSA 7) are mainly based in the French ports of Sète and Le Grau du Roi which group more than 60 % of the boats and insure about 70 % of the halieutic production of the Gulf of Lions and in the Spanish ports of Roses and Port de la Selva. *(42).* In 2010, 220 boats were involved in the demersal fishery: 111 French bottom trawlers, 67 French gillnetters, 27 Spanish bottom trawlers and 15 Spanish long-liners (tab.1), while 14 French purse seiners and 6 Spanish ones where fishing small pelagics in 2007-2008. Both fleets are subject to the rules of the EC Common Fisheries Policy, concretely to the management framework established by Council Regulation No 1967/2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea.

Countrty	Gear	Target sp.	nº of boats	Contribution
FR	Trawl	Demersal	111	50,45%
FR	Gillnet	Demersal	67	30,45%
SP	Trawl	Demersal	27	12,27%
SP	Longline	Demersal	15	6,82%

Tab.1.4- Composition of the French-Spanish fleet in 2010

French trawlers are the main component of the fleet exploiting the marine resources of the Gulf of Lions. This fleet can be divided into two main components, one (around 50 boats) directed to the catch of small pelagic species (mainly anchovy *Engraulis encrasicholus* and sardine *Sardina pilchardus*), the other characterised by the exploitation of a great diversity of demersal species.



Activité 2006 des navires de pêche de la région Languedoc-Roussillon © Ifremer, Juillet 2008

Fig.1.10- Spatial distribution of the activity of the French fleet in 2006

Main fisheries in GSA 6

Following the DCF criteria (EU, 2010), landings, effort and economic value of landings could be the criteria to select the main metier in an area. Applying this criteria, the main metier in the GSA06 will be bottom otter trawl targeting demersal species, bottom otter trawl targeting deep water species, purse seine targeting small pelagics, set longline targeting demersal species, trammel net targeting demersal species and gillnet targeting demersal species (Spanish National programme 2011-2013).

Bottom otter trawl targeting demersal species

Merluccius merluccius, Mullus barbatus, Mullus surmuletus, Nephrops norvegicus and *Octopus vulgaris* are the most commercially valuable species in the area and are an important component of a species assemblage that is the target of the bottom trawling fleets operating near shore.

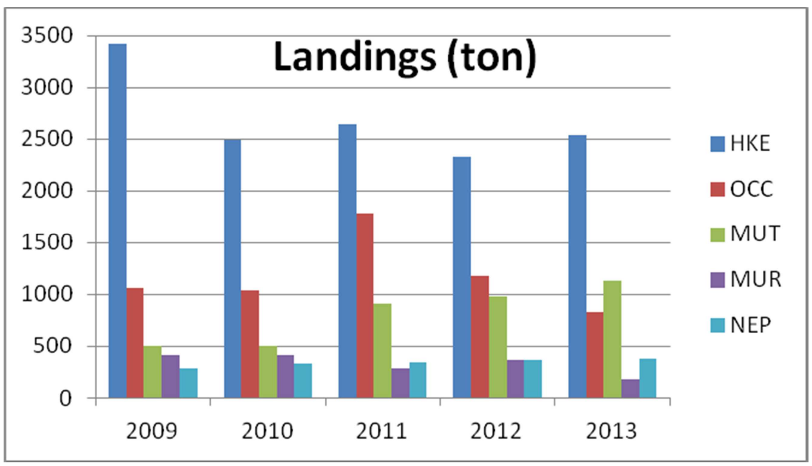


Figure 1.11. Landings of the target species in the métier OTB_DEF. Source of data: Mediterranean data call 2014

Bottom otter trawl targeting deep water species

Aristeus antennatus is the only target species of this metier. The bycatch is composed by *Lophius spp* and *Merluccius merluccius*.

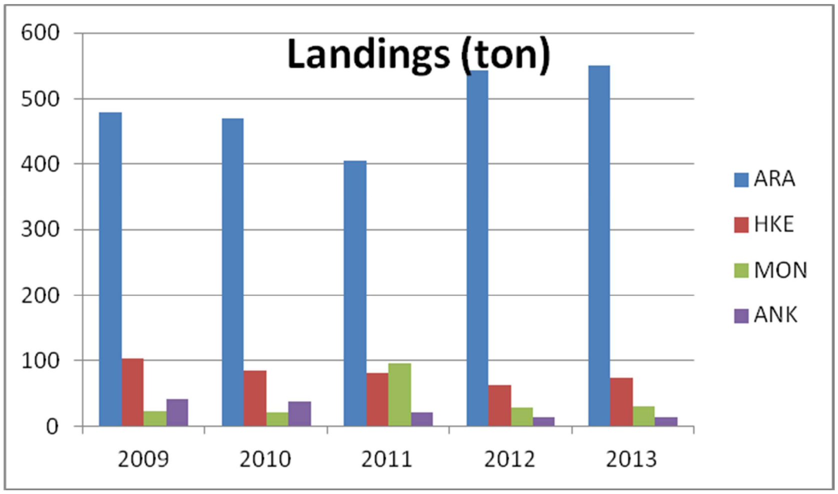


Figure 1.12. Landings of the target species in the métier OTB_DWS. Source of data: Mediterranean data call 2014

Purse seine targeting small pelagics

E. encrasicholus is the main target species of the purse seine fleet in Northern Spain, due to its high economic value. Catches in the period 1990-2012 has been highly variable (mean average value of 11500 tons), with a minimum of 2800 tons in 2007. Higher catches occurred in the period 1990-94, with values between 17000 and 22000 tons. The years with higher landings are usually correlated with a success of recruitment.

Sardine, even if with a lower price than anchovy, was an important support for this fishery until 2009 as it was the most fished species. In the period 1990-2012 sardine landings showed a decreasing trend, from 53000 t in 1994 to 9000 t in 2012. The whole period yearly average is 30000 tons.

The fishery is active throughout all the year, but the activity is higher in summer. In December and January there is the seasonal closure of the fishery. The main fishing grounds for anchovy are located in the Ebro Delta and the Rosas Bay, those for sardine are distributed throughout all the area.

Several species with a lower economical value are also caught, however they represent a low percentage of landings: the most abundant ones are *Trachurus* spp. *Scomber* spp. and *Sardinella aurita.*

The percentage of total discard (all species) in the purse seine fleet in GSA 6 ranges from 1% to 5%, depending of the year (pilot study 2003 and 2004 respectively). Discards are mainly composed of species with low or without economic value, like *B. boops* and *S. aurita*).

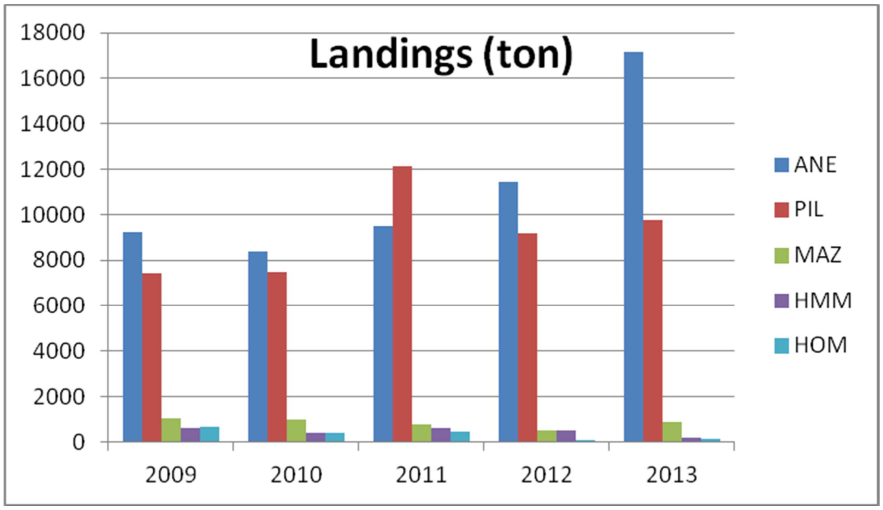


Figure 1.13. Landings of the target species in the métier PS_SPF. Source of data: Mediterranean data call 2014

The current fleet of GSA 6 (Northern Spain) in 2014 is composed by 118 units, with an average GT of 39.5 (Table 3). Also in this area the purse seine fleet has been continuously decreasing in the last two decades, from 222 vessels in 1990 to 118 in 2014. Between 2000 and 2014 has been lost 48.6% of the boats smaller than 40 GT (Fig. 9).

Table1.4.. Mediterranean Spanish small pelagic fleet LOA interval. Source of data: Spanish Ministry fleet register (2014). PS = purse seine.

Metier	Vessel Length	nº vessels	Average GT	Average LOA	Average kW
	VL0612	3	6.7	10.6	87
PS	VL1218	37	25.6	16.3	236.9
	VL1824	59	40.9	20.9	308.9
	VL2440	19	67.8	25.3	381.3
Total		118	39.5	19.9	292.3

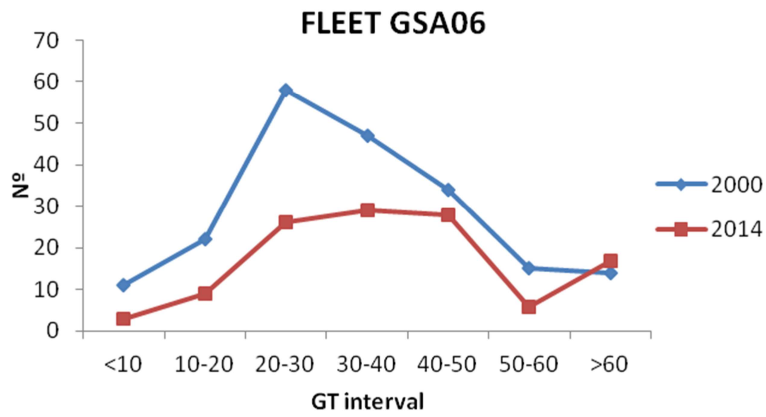


Figure1.14. Fleet GSA06 2000 and 2014 by GT interval.

The fleet is distributed in 19 ports in GSA 6. As concerns the number of vessels, the main harbours in the GSA 6 are Barcelona, Castellón, Tarragona y Vilanova (Table 4). This table shows the average technical characteristics for each of the ports from the North to the South ones.

Table 1.5. Ports, number of vessels and technical characteristics of the small pelagic fleet in GSA06.

GSA 06 2014		GT			Kw			LOA	
Port	Vessels	Total	Mean	SD	Total	Mean	SD	Mean	SD
Roses	6	254.0	42.3	21.5	1920.0	320.0	130.6	20.1	5.5
L'Escala	6	97.9	16.3	7.8	971.0	161.8	82.5	15.2	2.3
Palamós	4	119.8	29.9	5.8	907.0	226.8	55.7	16.4	1.5
San Feliú de Guisols	4	146.5	36.6	17.3	1196.0	299.0	68.7	19.4	1.4
Blanes	6	188.9	31.5	5.2	1306.9	217.8	60.4	19.7	2.0
Arenys de Mar	7	304.8	43.5	18.3	2450.0	350.0	57.7	20.8	3.4
Barcelona	21	795.3	37.9	14.6	6457.5	307.5	81.5	19.5	2.8
Vilanova i la Geltrú	9	283.4	31.5	16.0	2430.0	270.0	97.7	17.9	3.2
Tarragona	9	384.1	42.7	13.4	2628.0	292.0	81.0	19.4	2.9
Cambrils	4	133.1	33.3	5.5	1182.0	295.5	84.3	17.5	2.0
Ametlla de Mar	7	279.8	40.0	10.7	2379.0	339.9	142.4	20.7	1.2
Vinaroz	3	173.0	57.7	22.8	1337.0	445.7	23.8	23.5	1.4
Castellón	14	756.6	54.0	22.9	4740.0	338.6	108.2	23.2	3.1
Burriana	5	309.4	61.9	19.3	1859.0	371.8	96.5	24.5	2.1
Denia	1	20.6	20.6		120.0	120.0		15.5	
Javea	4	127.7	31.9	15.4	870.0	217.5	121.8	19.2	4.8
Altea	2	103.5	51.7	21.0	550.0	275.0	233.3	25.2	1.5
Torrevieja	5	156.2	31.2	18.0	896.0	179.2	57.4	17.9	5.0
San Pedro del Pinatar	1	31.93	31.93		295	295		18.9	
Total	118	4666.6	39.5	18.2	34494.5	292.3	107.1	19.9	3.7

Set longline targeting demersal species

Target species: *Merluccius merluccius*

Bycatch: *Sparus aurata* (SBG), *Pagellus bogaraveo* (SBR), *Diplodus spp* (SRG)

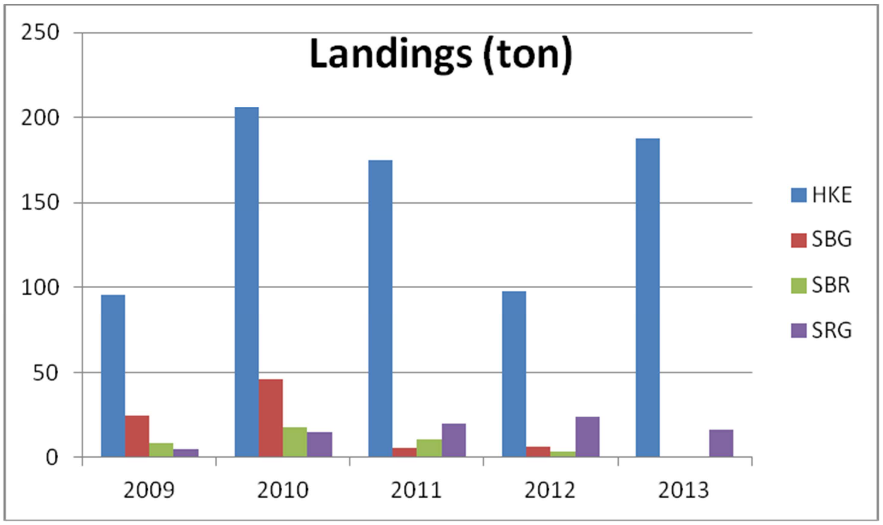


Figure 1.15. Landings of the target species in the métier LLS_DEF. Source of data: Mediterranean data call 2014

Trammel net targeting demersal species

Target species: *Sepia officinalis* (CTC), *Mullus surmuletus* (MUR), *Solea solea* (SOL)

Bycatch: Mullus barbatus, Merluccius merluccius

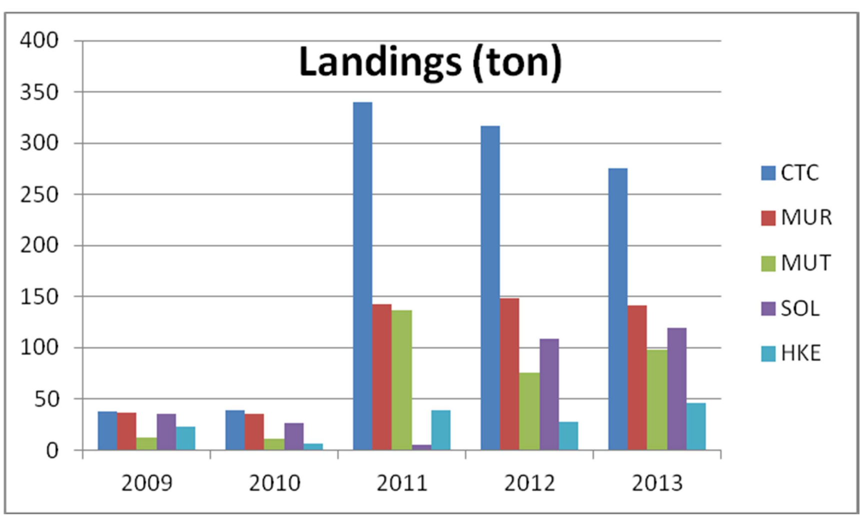


Figure 1.16. Landings of the target species in the métier GTR_DEF. Source of data: Mediterranean data call 2014

Gillnet targeting demersal species

Target species: *Merluccius merluccius*, *Sparus aurata* (SBG), *Diplodus spp* (SRG), *Pagellus erythrinus* (PAC), *Dicentrarchus labrax* (BSS), *Pagellus acarne* (SBA)

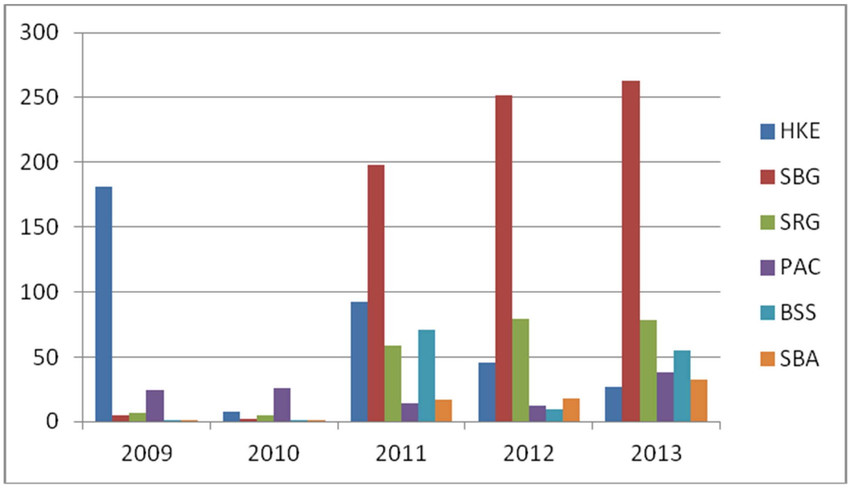


Figure 1.17. Landings of the target species in the métier GNS_DEF. Source of data: Mediterranean data call 2014

ECONOMIC PERFORMANCE

The total weight landed by the Spanish fleet in 2012 was 871 thousand tonnes of seafood, corresponding to €1.9 billion in landed value. There was also an increase in recreational catches, increasing 51% in 2012. The majority of catches (in weight) are from the distant-water fleet, 53% of the total catches, whereas only 9% of the catches are from the Mediterranean Sea (area 37).

In the case of the Mediterranean, the information gathered shows a low level of disaggregation. In fact, the data refer to the total area FAO 37 without dividing the corresponding GSA's (1, 5 and 6). Nor is there a fine division between metiers, although it appears disaggregated between major arts.

The amount of income generated by the Mediterranean Spanish fleet in 2012 was €293.6 million. This consisted of €293.5 million in landings value and €0.1 million in non-fishing income. The Spanish fleet's income decreased 4% between 2011 and 2012, caused by the small scale fleet that suffered a 31% decrease in income. The reduction on small scale fleet's income was a result of a reduction in the number of vessels. On the other hand, purse seine fleet's income increased 20%. Total operating costs incurred by the Mediterranean fleet in 2012 equated to €281.7 million, amounting to 94% of income. Crew and fuel costs were the two major fishing expenses in 2012 representing 30% and 23% of total income respectively.

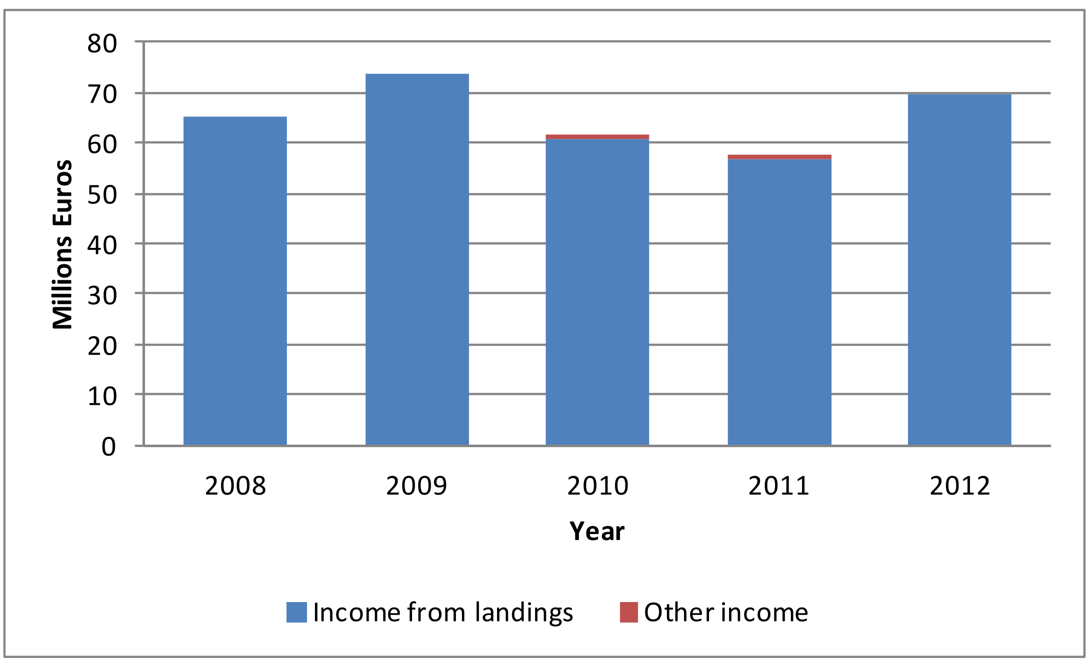


Figure 1.18. Spanish Mediterranean purse seine fleet main economic performance trends for the period 2008-2013.

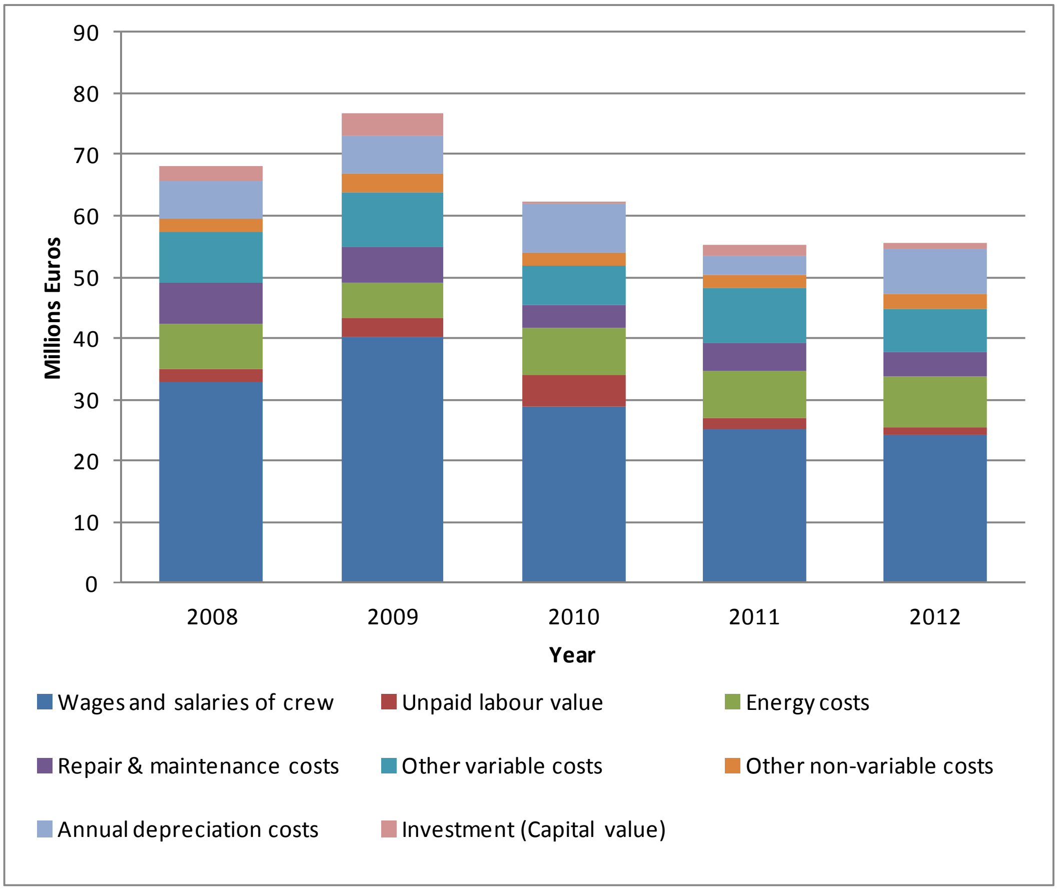


Figure 1.19. Spanish Mediterranean purse seine fleet main economic performance trends for the period 2008-2013.

In 2012, according to the official statistics of the Ministry for Agriculture, Food and Environment (http://www.magrama.gob.es), the Spanish fishing fleet decreased the number of vessels in order to bring it in balance with the resources. This trend is also reflected in the reduction of engine power and gross tonnage. Between 2011 and 2012, the size of the fleet (measured by vessel tonnage) reduced 5%, which particularly affected the small scale fleet. Profitability of the fleet improved in 2012 motivated by operating cost reductions, but specifically in crew and energy expenses. The number of inactive vessels increased a 39% in 2012, another factor contributing to improved profitability in the sector.

Effort data and landings data was only provided for the years 2012 and 2013 (value of landings provided only for 2012). Data collection for Spain is difficult due the size and complexity (by fishing areas and technology) of the Spanish fishing fleet.

The inter-annual variation in the composition of the small and large-scale fleets is in part due to the methodology used to define each type of fishing technology. Small-scale vessels are defined as vessels less than 12 m using non-towed gears. If from one year to the next, a vessel with 12 m or less changes it main gear type (used in more than 50% of the fishing effort in a given year) from a passive gear (e.g. HOK - hook) to an active gear (e.g. PS – Purse seine), it will no longer be defined as small-scale but instead as a large-scale vessel.

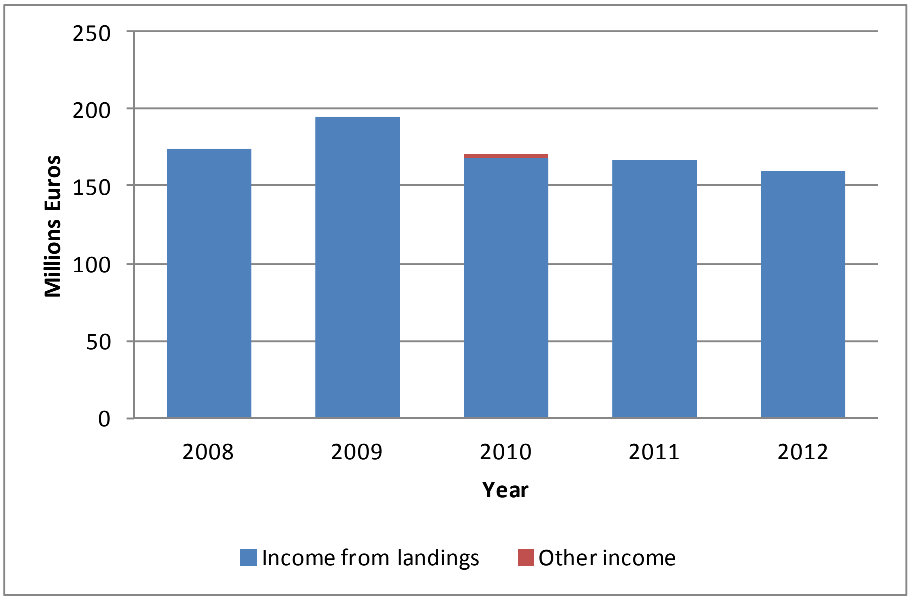


Figure 1.20. Spanish Mediterranean trawl fleet main economic performance trends for the period 2008-2013.

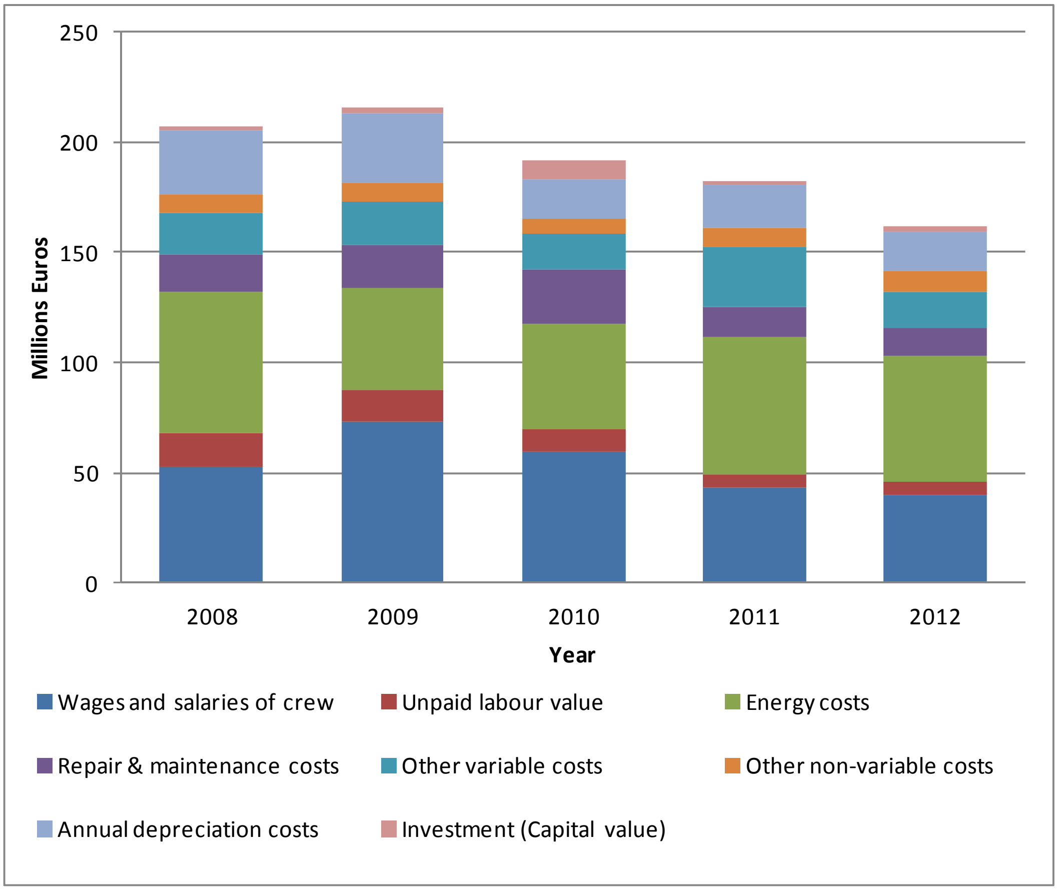


Figure 1.21. Spanish Mediterranean trawl fleet main economic performance trends for the period 2008-2013.

NORTH-WESTERN MEDITERRANEAN WATERS

Spatial distributions of the main stocks

In the areas of study, GSA 6 and GSA 7, there are several commercially important populations of demersal species of fishes, crustaceans and molluscs. A number of these species are clearly coastal, i.e. grey mullets (*Mugilidae*), sea breams (*Sparus aurata*), sea bass (*Dicentrarchus labrax*), some shrimps and many molluscs. The upper zones of the continental shelf are inhabited by species like red mullets (*Mullus barbatus, Mullus surmuletus*), sole (*Solea solea*), gurnards (*Trigla sp.*), poor cod (*Trisopterus minutus capelanus*), Black Sea whiting (*Merlangius melrangus*), and some shrimps. On the continental slope there are many fish species of great economic interest. Thus in the upper part of the slope (200 and 400m) there are hake (*Merluccius merlucci*us), Norway lobsters (*Nephrops norvegicus*) and various shrimps (e.g. *Peneus longirostris*). In deeper waters, from 400 to 600m, the dominant species are the greater forkbread (*Phycis blennoides*), the blue whiting (*Micromesistius poutassou*) and the red shrimps (*Aristeus antennatus, Aristaemorpha foliacea*).

A Project that considers the spatial coverage of fisheries and stocks in the Mediterranean (STOCKMED) was carried out recently. As results of the application of the STOCKMED methodological framework, the most plausible Hypotheses of stock structure of 19 fish and shellfish species of fishery interest in the Mediterranean have been identified. The hypotheses were evaluated in terms of 7 independent criteria (Genetics, Parasites, EFH and connectivity, Growth, L50, Density trends, Biomass trends).

Table 1.6. The most significant correlations in density between contiguous GSAs, number of observation (pairs of years), the coefficient of correlation for each species and the number of the species in which each correlation has been found. Only statistically significant correlation coefficients (p-value < 0.05) are shown.

Correlated GSAs		pairs of years	*A. foliacea*	*A. antennatus*	*E. cirrhosa*	*E. moschata*	*E. encrasicolus*	*G. melastomus*	*I. coindetti*	*L. budegassa*	*M. merluccius*	*M. barbatus*	*M. surmuletus*	*N. norvegicus*	*O. vulgaris*	*P. erythrinus*	*P. longirostris*	*S. vulgaris*	*T. mediterraneus*	*T. trachurus*	number of species showing significant correlation
1	2	5											0.87		0.9						2
1	5	5											0.9								1
1	6	10			0.72									0.85							2
5	6	5	0.87	0.9													0.83				3
5	11	5																			0
6	7	10							0.6							0.77				0.6	3
6	8	9							0.73												1
6	11	10									0.58					0.81					2
7	8	9							0.71	0.6	0.58	0.6				0.91	0.75		0.8		7
7	9	10						0.67			0.76						0.64		0.62		4
8	9	9															0.89				1
9	10	10											0.6		0.58	0.68					3
9	11	10			0.61									0.7							2
10	11	10				0.56															1
10	16	10						0.76	0.56		0.9		0.68								4
15	16	10						0.83	0.59	0.56				0.61							4
15	19	10					0.62													0.58	2
16	19	10								0.6											1
17	18	10					0.65			0.7											2
18	19	10																		0.82	1
18	20	5														0.77			0.9	0.83	3
19	20	5		0.82													1				2
20	22	5																			0
Number of pairs of GSAs with significant correlation			1	2	2	1	2	3	5	4	4	1	4	3	2	0	5	5	0	3	

Referring to the biomass index, the pair of contiguous GSAs with highest amount of time series of species correlated was the Gulf of Lions (GSA 7) and Corsica (GSA 8) with 7species significantly correlated, while two additional pairs showed 5 species with significantly correlated time series, i.e. Northern Alboran Sea (GSA 1) and Northern Spain (GSA 6), Northern Spain (GSA 6) and Gulf of Lions (GSA 7). Nevertheless, some of the results show that the biomass values relationships between areas (GSA 6-GSA 7, in ae.) were not significant for the main species considered in the trawl fishery.

However, low proportion of species showing synchronisms is found in adjacent GSAs: highest amount of species with positive and significant correlation was 7 species out of the 19 STOCKMED target species (37% of the STOCKMED target species). Thus, from a biological point of view merging several GSAs in order to establish management boundaries seems not advisable. It might be useful to elaborate similar correlation matrices for the rest of the biological parameters in order to confirm this conclusions.

The report of the STOCKMED project was revised by the STECF in its Plenary meeting of November 2014.

STECF was not able to compare the validity and robustness of the stock units proposed under the STOCKMED project with the existing GFCM-GSAs limitations. However, STECF considered, the new stock unit's configuration should be checked against the major requirements for stock assessment, i.e. productivity and population isolation (i.e. self-sustained sub-populations with no major migration and immigration among neighbouring units and with separate spawning areas). While the latter cannot be checked due to lack of data, the second can be roughly done through the analysis of differences between the old and new stock configuration in productivity as for example k, density, Lmax, natural mortality rates and other features.

STECF also considered that the consequences of the new stock configuration need to be evaluated in terms of data collection and processing, stock assessment and management advice. STECF consider that these aspects need further consideration before final conclusions about a new stock configuration can be made and that this would be best advanced through a dedicated expert group.

(http://stecf.jrc.ec.europa.eu/documents/43805/896390/2014-11_STECF+PLEN-14-03_JRC93037.pdf).

Hake (*Merluccius merluccius*)

In the Mediterranean its bathymetric distribution is wide, between 30 and 1000 m depth, although the highest abundances are registered between 70 and 370 m depth, been very scarce at depths below 500 m. (Oliver & Massutí, 1995; Orsi Relini *et al*., 2002). The analysis of data from MEDITS surveys suggests that the main concentrations of recruits (age 0 individuals) and juveniles are located between 100-150 m depth, while older individuals are most abundant on the slope (Orsi Relini *et al*., 2002).

Merluccius merluccius - **Cells of potential or effective presence**

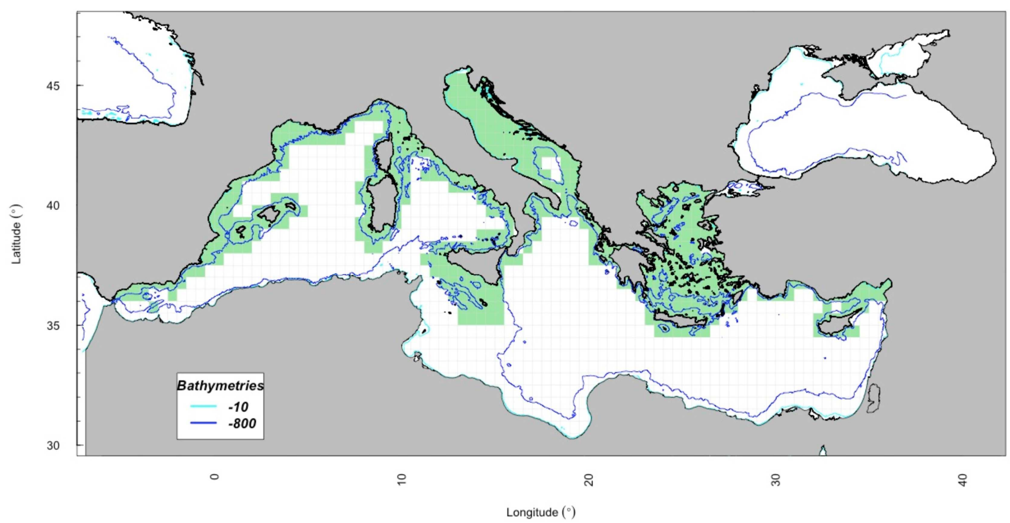


Figure 1.22 Spatial distribution of effective presence of *Merluccius merluccius* in the Mediterranean.

As a STOKMED result, the distribution of the mean Cohen's Kappa indicates the "6 stock units" as the configuration with the best agreement followed by the configurations with 5, 7 and 4 units. The acceptability analysis reinforces these results. Indeed the hypotheses with 6 units (HAI= 0.95), 7 units (HAI=0.90) and 5 units (HAI=0.85) present high acceptability indices for the best ranks and are taken as candidates for the best hypothesis of stock structure. In particular, the "6 stock units" is considered the most plausible stock structure hypothesis based on currently available knowledge.

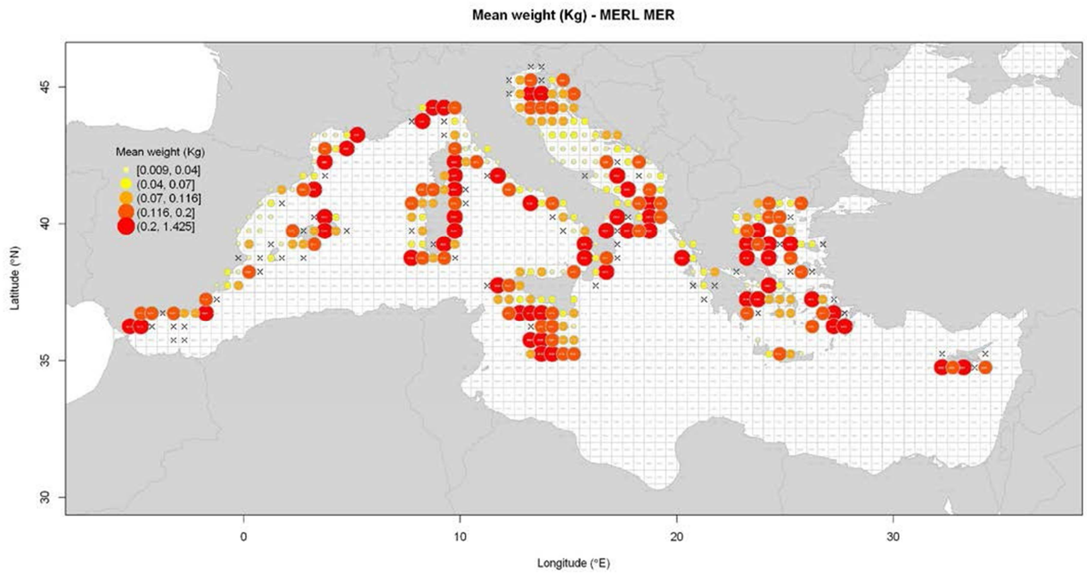


Figure 1.23. Biological indicators (Biomass) from 10 years of MEDITS surveys (2002-2011) for *.Merluccius merluccius.*

In this configuration few zones, i.e. the Gulf of Lions and the coast offshore northern Spain, the Gulf of Lakonikos along the Peloponnesus, and the area western to Adalia (Turkey) presented a slight mixture of elements belonging to two different contiguous clusters from neighbour GSAs, possibly as a result of the influence of some thematic descriptors (in these cases probably genetics, EFH and connectivity and growth. the joining of the intermixed elements to the main neighbour areas is suggested, according to the following table 3.1, in which the two units of the North Adriatic are joined, while the Gulf of Lion and the northernmost side of north Spain (GSA 6) were associated to the same cluster as GSAs 1 and 5. It should be also taken into account that in GSAs 6 and 7, as well as in GSA17 hake is also considered a shared stock by GFCM. Finally the trade-off for the most suitable configuration is based on 5 stock units

This means that *M. merluccius* populations from GSA's 1, 5, 6 and 7 are considered as a single stock.

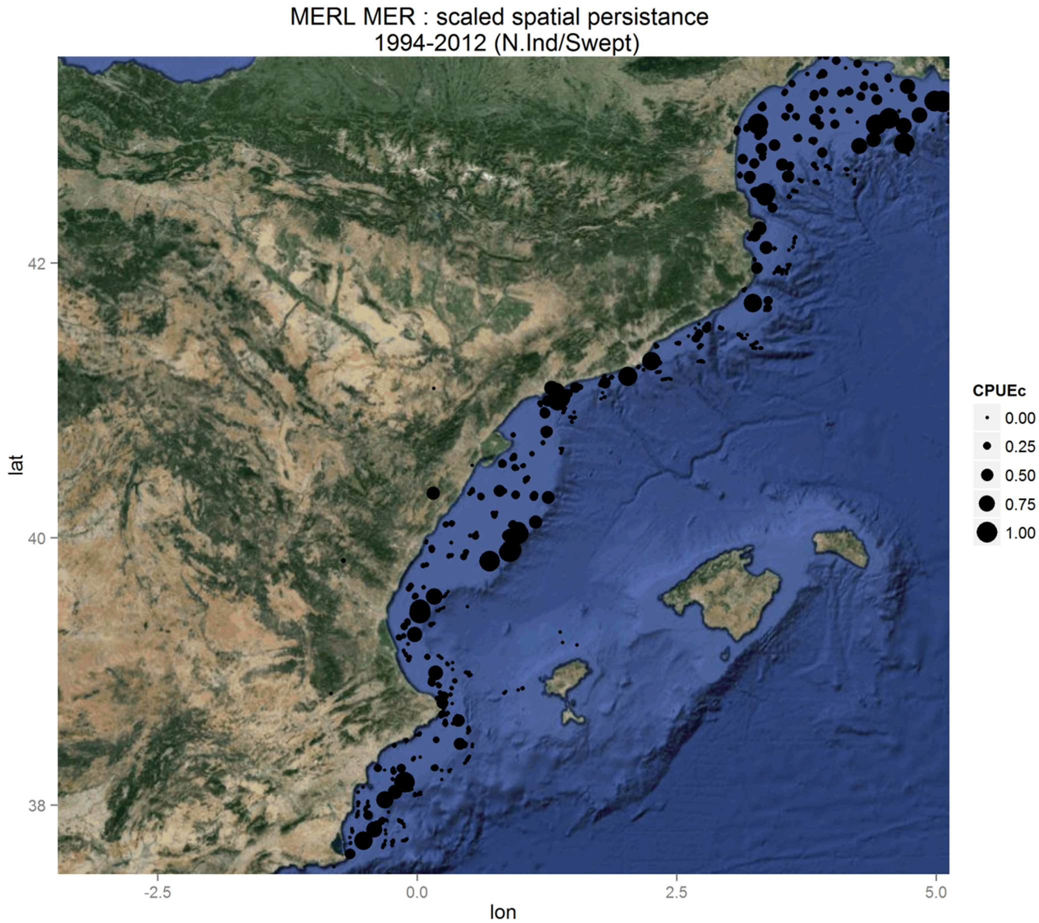


Figure 1.24. Geographical distribution of abundances (nº / km2) and distribution of *Merluccius merluccius* in GSA 6 and GSA 7 during MEDITS_ES surveys.

M. merluccius is widely distributed in the studied areas. Its abundance are greater in the shelf-slope break than in the shelf, both in the GSA 6 as in GSA 7.

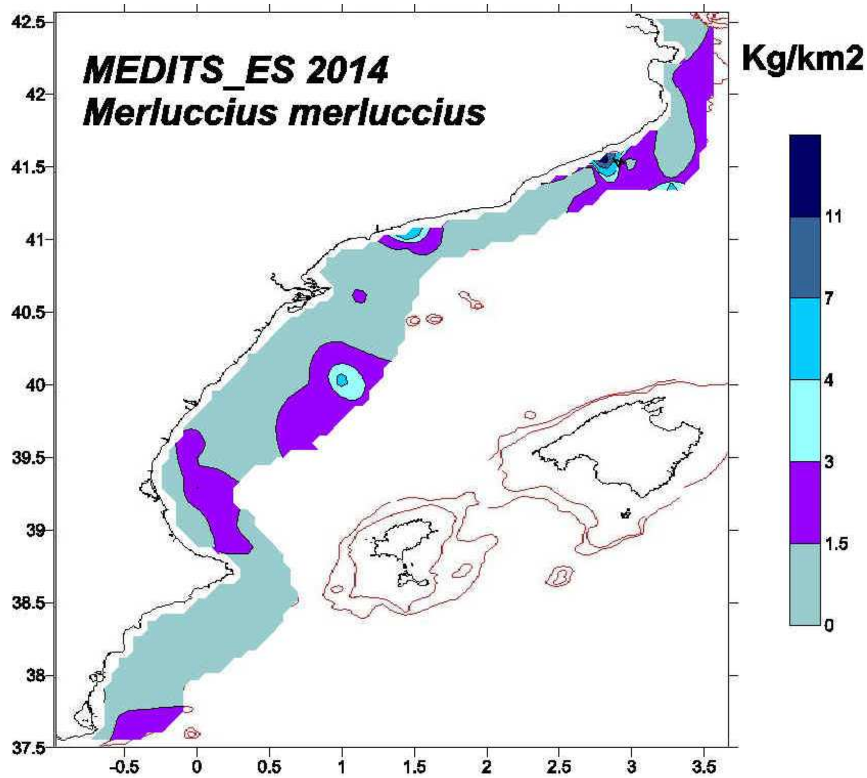


Figure 1.25. Geographical distribution of yields (kg / km2) and distribution of *Merluccius merluccius* in GSA 6 during MEDITS_ES 2014 survey.

In the GSA 6, hake it is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are located in Cabo de Palos, Gulf of Valencia, Columbretes Islands, Badalona, Blanes and Cap de Creus.

In the Gulf of Lions (GSA 7) hake is also one of the most important demersal target species for the commercial fisheries. In this area, hake is exploited by French and Spanish trawlers, French gillnetters and Spanish long-liners. Around 240 boats are involved in this fishery; according to official statistics the total annual landings for the period 1998-2012 have oscillated around an average value of 2030 tons (1123 tons in 2012). The French trawler fleet is the largest in number of boats and catch (42 boats and 72% of the total catch). The length of hake in the trawler catches ranges between 3 and 92 cm TL, with an average size of 21 cm TL. The French gillnetters is the second largest fleet (~41 boats and 14% of the total catch), the size of fish range between 13 and 86 cm TL and an average size of 39 cm TL. Spanish trawlers account to 11 boats and 8% of the total catch, the size of fish in catch range between 5 and 88 cm TL, and the average size is 24 cm TL. Finally, the Spanish long-liner fleet is composed by ~6 boats and account for 6% of the catch, size composition of catches range between 22 and 96 cm TL, with an average size of 52 cm TL.

The catch is dominated by the french trawlers fleet. Since 1978, the catch has been slowly decreasing. In 2013, the total catch reached 1735 tons. The hake trawlers exploits a highly diversified species assemblage: Striped mullet (*Mullus surmuletus*), Red mullet (*Mullus barbatus*), Anglerfish (*Lophius piscatorius*), Black-bellied anglerfish (*Lophius budegassa*), European conger (*Conger conger*), Poor-cod (*Trisopterus minutus capelanus*), Fourspotted megrim (*Lepidorhombus boscii*), Soles (*Solea* spp.), horned octopus (*Eledone cirrhosa*), squids (*Illex coindetii*), Gilthead seabream (*Sparus aurata*), European seabass (*Dicentrarchus labrax*), Seabreams (*Pagellus* spp.), Blue whiting (*Micromesistius poutassou*) and Tub gurnard (*Chelidonichtys lucerna*).

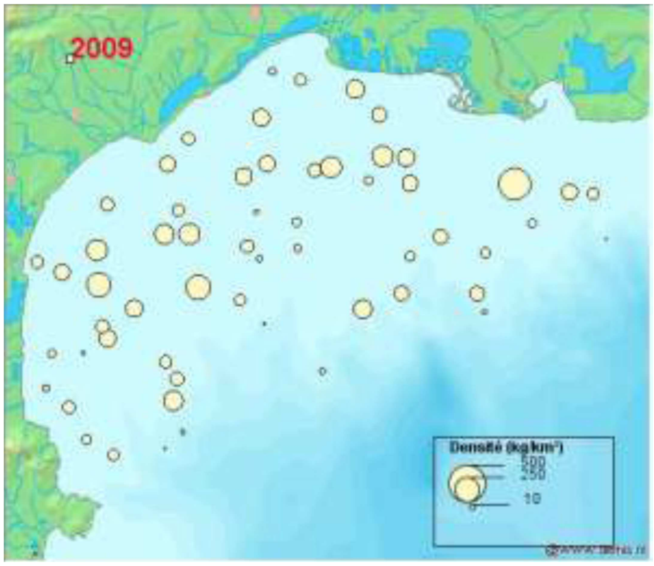


Figure 1.26. Geographical distribution of yields (kg / km2) and distribution of *Merluccius merluccius* in GSA 7 during 2009.

The hake (*Merluccius merluccius* L., 1758) is a demersal species very widely distributed in the Gulf of Lions since the very coastal sector, near 30m depth, until 800 m. The species is mainly present between 80 and 150 m. Eggs and larvae are present preferentially on the continental shelf with a peak of abundance between 100 and 200 m. The O group is very abundant from June till November between 100-150m. The higher densities are located on the upper border of the slope at depths lower than 200 m *(100).* The age group 1 (15-18cm) is dominant in these same places but can also be met in the coastal zone while the group 2+ occupies the whole shelf with variable but particularly important spatiotemporal concentrations on the border of the continental slope and on the upper part of the canyons.

Red mullet *(Mullus barbatus)*

Two species of the genus *Mullus* (*M. barbatus* and *M. surmuletus*) are present in the Western Mediterranean. Both of them have a high commercial value and are the main target species of many demersal fisheries. They are sympatric species with a similar geographical distribution that includes the continental shelf and coastal areas, although some differences in the geographical and bathymetrical distribution are observed in the Iberian Peninsula (Lombarte et al., 2000; Demestre et al., 1997).

M. barbatus occurs on sandy and muddy bottoms between 50 and 200m depth in areas with wider continental shelf, whereas *M. surmuletus* has a wider bathymetric range (occurring to a depth of 400 m) but its maximum abundance is concentrated near the coast, on gravel and rocky bottoms between 10 and 100m depth, especially in areas where the shelf is steepest and with a higher influence of seagrass beds, especially *Posidonia oceanica* (Demestre et al., 1997). The mean size of the individuals of both species, especially M. surmuletus, increases with depth due to the reproductive movement of adults individuals towards the deep shelf and upper slope bottoms in spring (Lombarte et al., 2000).

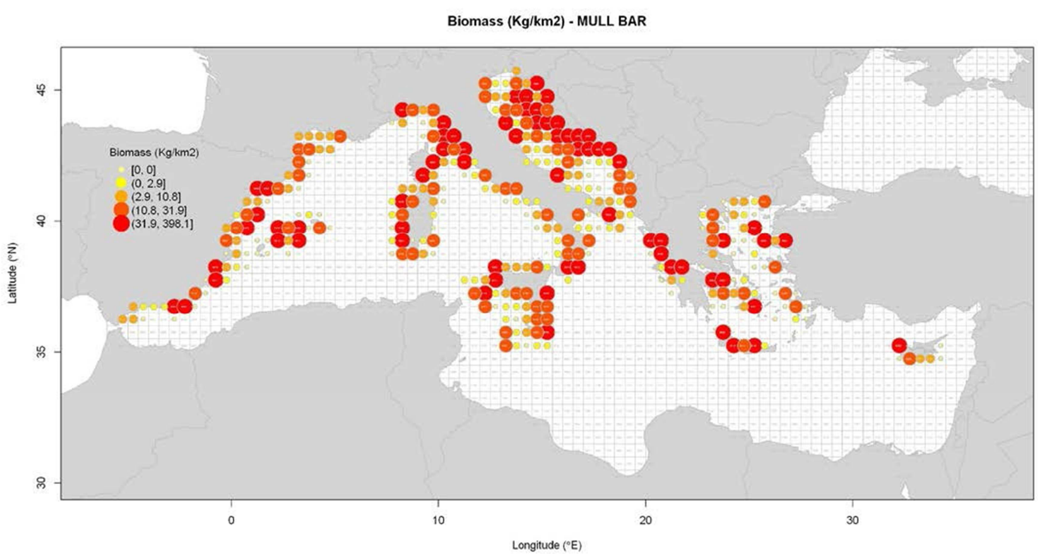


Figure 1.27. Biological indicators (Biomass) from 10 years of MEDITS surveys (2002-2011) for *.M. barbatus.*

The mean Cohen's Kappa, based on four layers of information (Genetics, Growth, Biomass trends and Oceanographic systems–surface), shows a peak at 3 clusters. The other configurations located above the upper quintile of the distribution are those with 2, 4, and 5 clusters. According to the acceptability analysis, all these candidate hypotheses receive some degree of acceptability for the highest ranks. In particular, considering the first rank acceptability index, the 3 clusters configuration appears more plausible than the 4 clusters configuration even if its HAI is lower (0.60 against 0.81). Taking into account the high number of descriptors used in the holistic approach, 6 biological indicators and 4 thematic layers of information, the results for red mullet are considered plausible.

Two hypotheses among those considered more likely in WP4 have been selected: the 3 units (Holistic Acceptability Index= 0.6) and the 4 units (HAI=0.81) hypothesis. Both were robust because based upon 6 biological indicators and 4 thematic layers. However the first one was also characterized by a higher Cohen's Kappa coefficient (0.6) and higher ranked in the quintile distribution. Thus the 3-units hypothesis is selected.

This means that *M. barbatus* populations from GSA's 1,5, 6 and 7 are considered as a single stock, being extended the limits to the Western Ionian Sea.

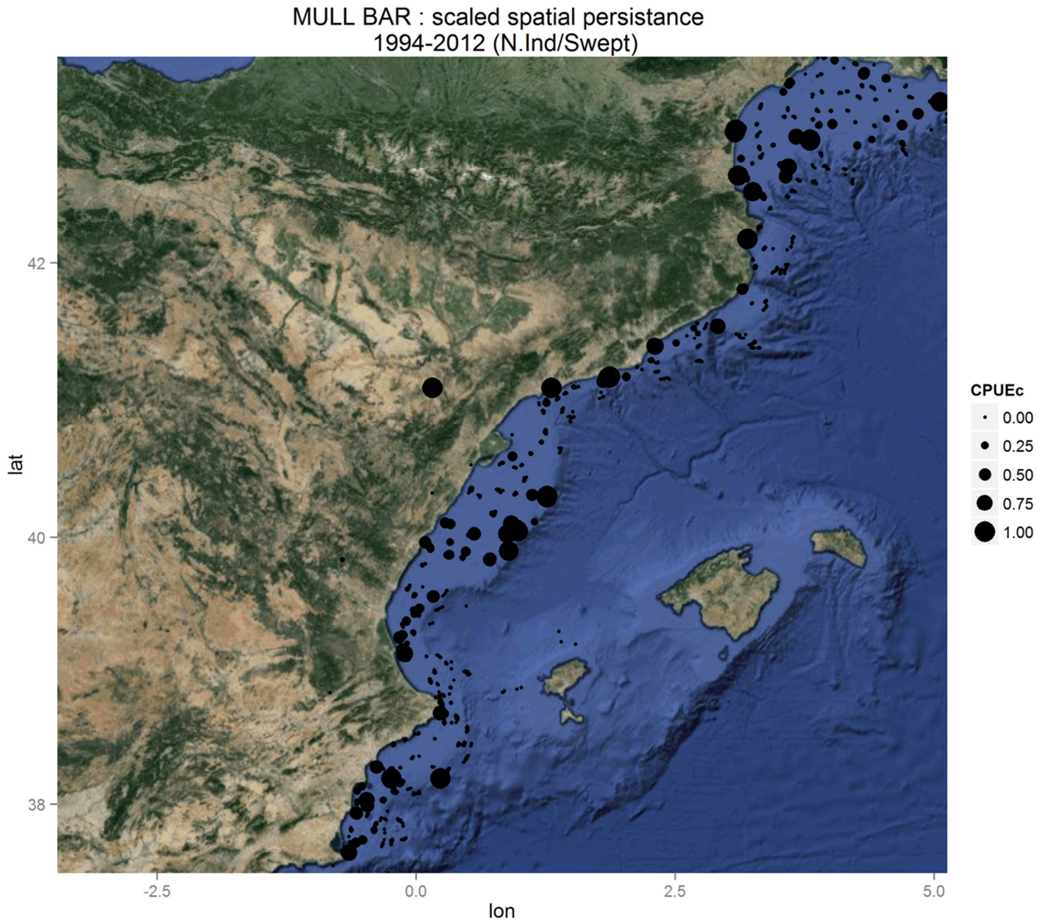


Figure 1.28. Geographical distribution of abundance (nº / km2) and distribution of *Mullus barbatus* in GSA 6 and GSA 7 during MEDITS_ES surveys.

M. barbatus is widely distributed in the studied areas. Its abundance is greater in the shelf-slope break than in the shelf, both in the GSA 6 as in GSA 7.

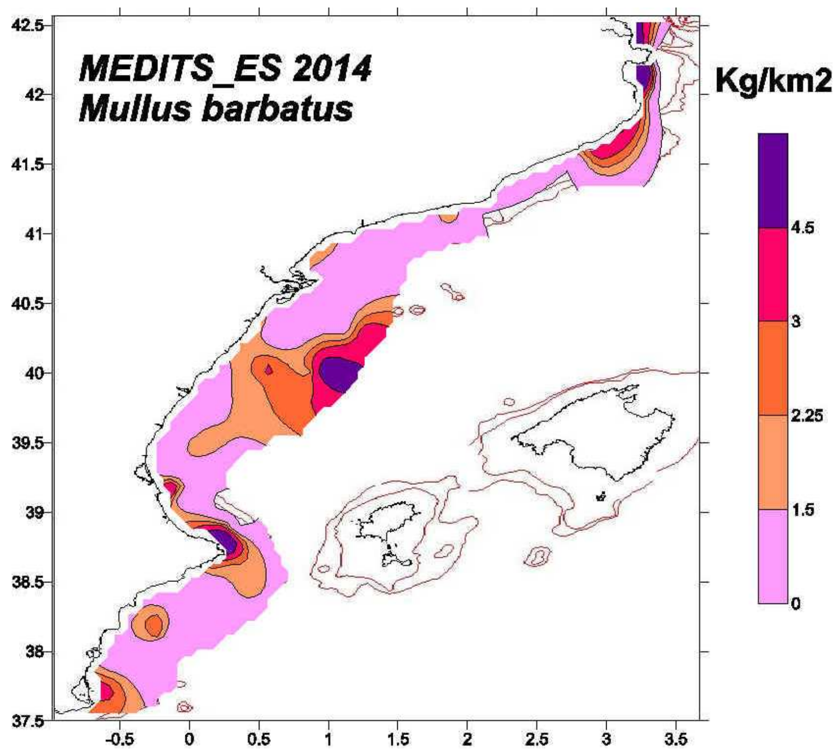


Figure 1.29 Geographical distribution of yields (kg / km2) and distribution of *Mullus barbatus* in GSA 6 during MEDITS_ES 2014 survey.

In the GSA 6, mullet (*M. barbatus*) it is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are located in Cape de Palos, South of the Gulf of Valencia, Columbretes Islands and Blanes-Cap de Creus.

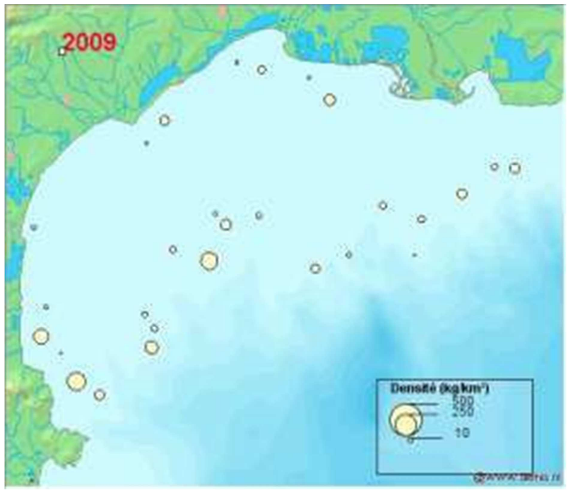


Figure 1.30. Geographical distribution of yields (kg / km2) and distribution of *Mullus barbatus* in GSA 7 during 2009.

Stripped red mullet (*M. surmuletus*) is caught in GSA 6 mainly by bottom trawlers fishing on the continental shelf, between 50 and 200 m depth. It is also caught by trammel nets, but in a lower proportion, representing in general less than 10% of total catches. OTB landings of red mullet in GSA 6 oscillated between a minimum value in 2002 (300 t) and a maximum (1700 t) in 2004, with an increasing trend during the last years (from 2010). GTR landings were always lower than 150 t.

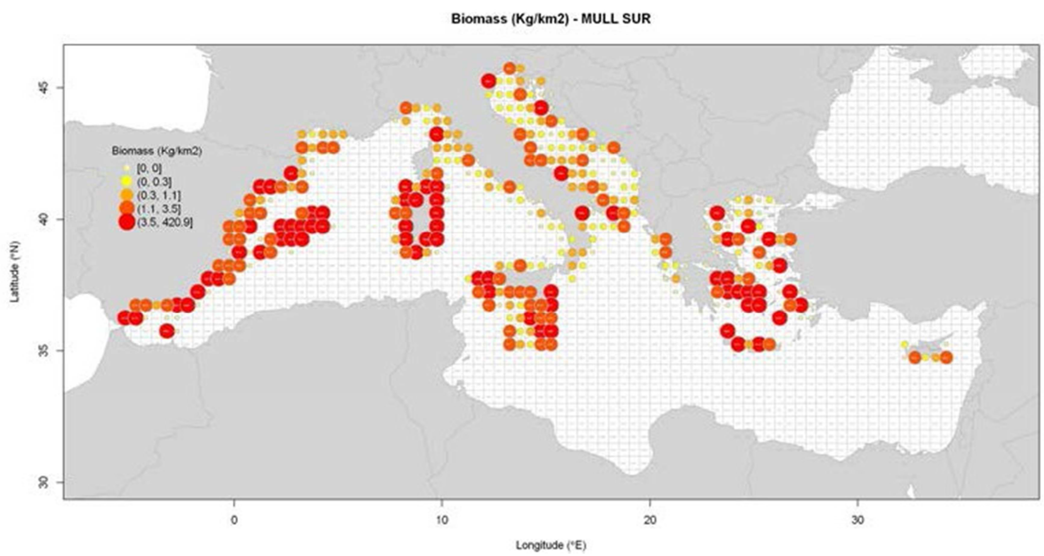


Figure 1.31. Biological indicators (Biomass) from 10 years of MEDITS surveys (2002-2011) for *.M. surmuletus.*

In the case of *M.surmuletus*, the CC was performed on only three biological indicators (Biomass index, CV % of density, mean fish weight). The graph of the mean Cohen's Kappa, evaluated on five layers of information (Genetics, L50, Biomass trends, Density trends and Oceanographic systems–surface), shows a plateau between the configurations with 5 and 8 clusters, being the last the highest value. Considering the hypotheses falling above the upper quintile (5, 6, 7, and 8 units), the acceptability analysis suggests that the two best ranked hypotheses are the “6 stock units” (HAI=0.80) and the “8 stock units” (HAI=0.79). However the “6 stock units” also presents the highest first rank acceptability index. Based on currently available knowledge, the results for *M.surmuletus* are considered plausible.

Two hypotheses among those considered more likely in WP4 have been selected: the 6 units (Holistic Acceptability Index= 0.8) and the 8 units (HAI=0.79) hypothesis. Both were based upon 3 biological indicators from the survey (the inverse of CV of density index, the biomass index and the mean weight) and 5 thematic descriptors (Genetics, L50, Biomass trends, Density trends and Oceanographic systems– surface) with scattered information among the GFCM GSAs. The 8 units hypothesis had the higher Cohen's Kappa coefficient, though the 6 units hypothesis was rather equivalent in terms of ranks in the quintile distribution and had the first rank acceptability index. In addition, it appeared less affected by possible spurious signs in the constrained clustering process. Thus the 6-units hypothesis is selected.

This means that *M. surmuletus* populations from GSA's 1, 5, and 6 are considered as a single stock, being extended the limits to the Gulf of Lions (GSA 7).

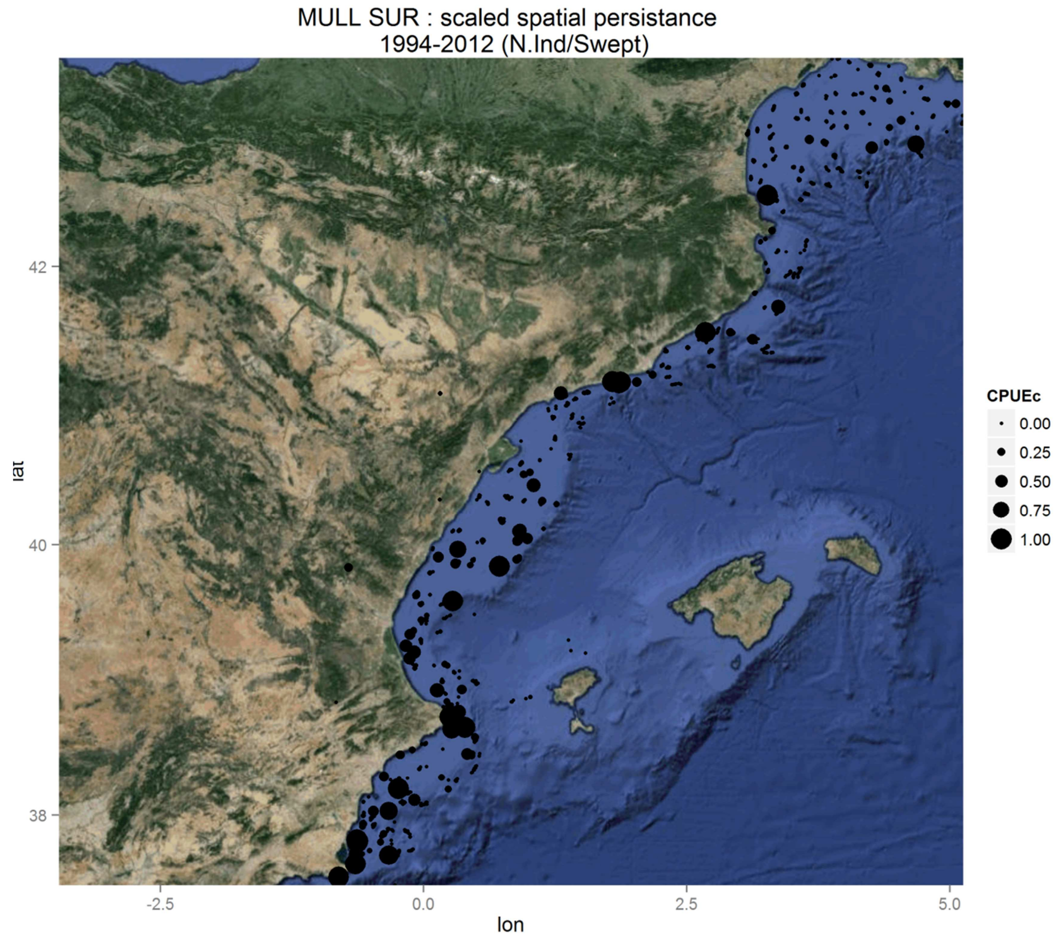


Figure 1.32. Geographical distribution of abundance (nº / km2) and distribution of *Mullus surmuletus* in GSA 6 and GSA 7 during MEDITS_ES surveys.

M. surmuletus appears to be widely distributed in the studied areas. Its abundance is greater in the shelf than in the shelf-slope break, both in the GSA 6 as in GSA 7.

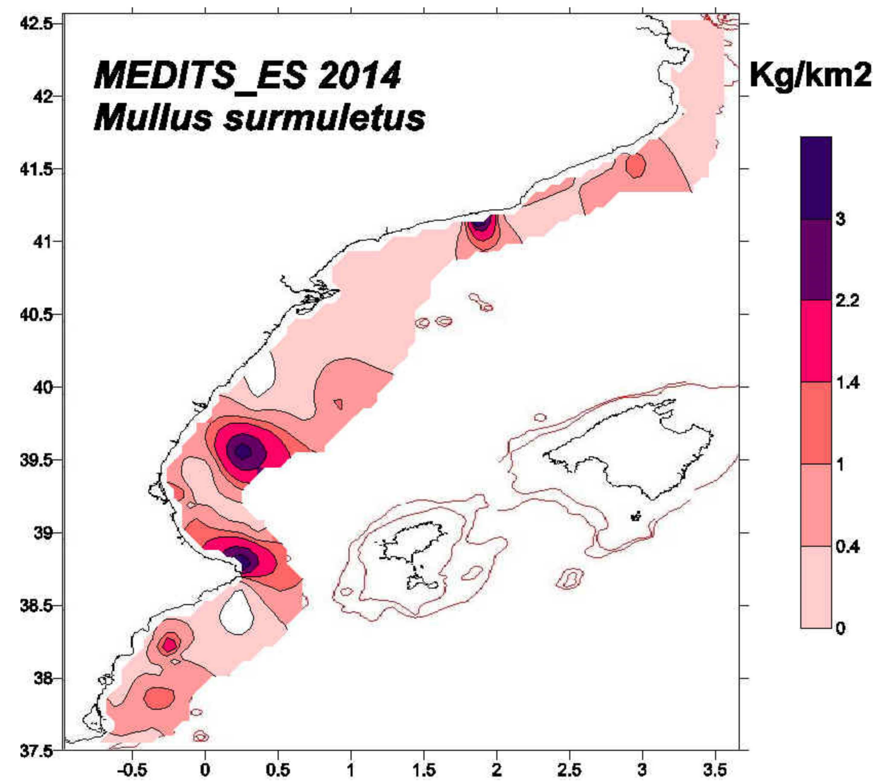


Figure 1.33. Geographical distribution of yields (kg / km2) and distribution of *Mullus surmuletus* in GSA 6 during MEDITS_ES 2014 survey.

In the GSA 6, red mullet (*M. surmuletus)* it is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are located in Santa Pola-Alicante, South of the Gulf of Valencia, in front of Valencia-Sagunto, Columbretes Islands, Barcelona and Blanes.

In the Gulf of Lions (GSA 7), red mullet is exploited by both French and Spanish trawlers. Information on French gillnetters is only available for 2011 and 2013, but although it is suspected that they have been fishing red mullet in the past, no data is available to quantify their catches. Between 2004 and 2013, around 100 boats have been involved in the fishery. According to official statistics, during this period the total annual landings have oscillated around an average value of 200 tons and the French trawlers have been dominating the fishery, as they represent 73% of the catches (165 tons) on the period. After 2009, because of the large decline of small pelagic fish species in the area, the trawlers fishing small pelagic have diverted their effort on demersal species, this can explain the high catches of 2010. Between 1998 and 2013, the number of French trawlers operating in the GSA 07 has decreased by 39%, while it decreased by more than 30% between 2010 and 2013. From a maximum number of 123 trawlers in 2004, the French fleet catching red mullet is nowadays composed by 61 units. This follows management measures to reduce the number of boats.

Pink shrimp (*Parapenaeus longirostris*)

The trawl feet operating in GSA06 in 2012 consisted of 540 trawlers, according to the statistics of the Autonomous Governments of Valence (269 vessels in southern GSA06) and Catalonia (271 in northern GSA06). Some units (smaller vessels) operate almost exclusively on the continental shelf (targeting red mullet, octopus, hake and sea breams). Larger vessels operate almost exclusively on the upper and middle slope (targeting decapod crustaceans). The rest can operate indistinctly on the continental shelf or slope fishing grounds, depending on the season, the weather conditions and also economic factors (e.g. landings price). The percentages of these trawl fleet segments have been estimated at around 30, 40 and 30% of the boats, respectively (Alemany and Álvarez, 2003). Note that the trawl fleet in GSA 06 has been decreasing by approximately 10% units annually over the last 2 years due to the Integral Management Plan for Mediterranean fisheries for the years 2011-2012. It is estimated that half of the trawl fleet operates on deepwater pink shrimp fishing grounds (270 units) and other deep-water fishing grounds, targeting other valuable crustaceans (Norway lobster; red shrimp).

Deepwater pink shrimp is distributed from 150 to 400 m depth in GSA 06, with higher densities on soft muddy bottoms in the southern part of GSA and, in years of high abundance of the population also in the north of GSA 06.

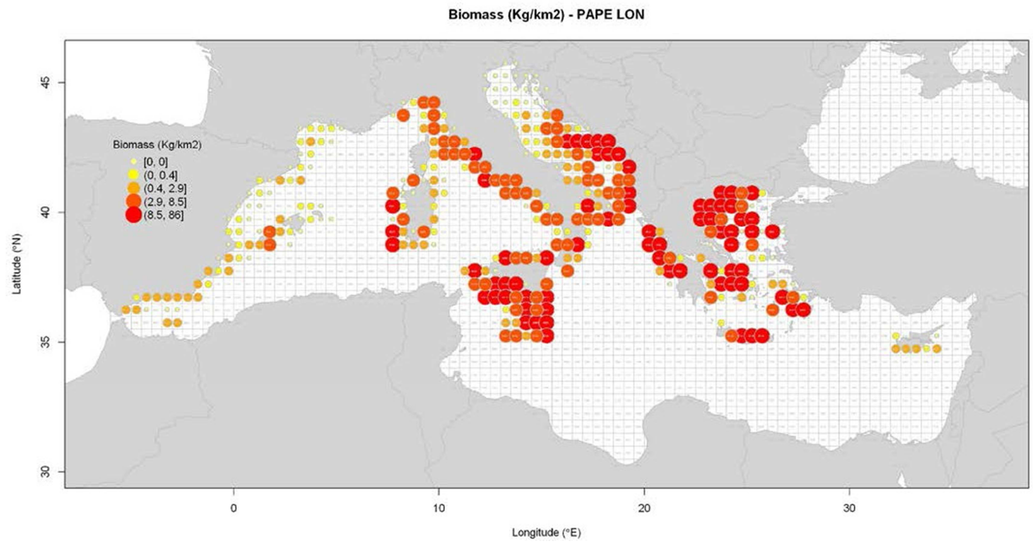


Figure 1.34. Biological indicators (Biomass) from 10 years of MEDITS surveys (2002-2011) for *P. longirostris*.

The full set of MEDITS biological parameters (Biomass index, CV % of density, mean fish weight, sex ratio, % of spawning females, median length of spawning females) was used in the CC to generate stock structure hypotheses of Deep-water pink shrimp. The mean Cohen’s Kappa, evaluated on five layers of information criteria (Genetics, EFH and connectivity, Spawning season, Density trends, Biomass trends), results rather flat in the region from 3 to 9 clusters. The configurations with 5, 6, 7, and 8 units are within the upper quintile of the distribution with the “5 stock units” configuration exhibiting the highest mean Cohen’s Kappa.

According to results of acceptability analysis, the four candidate configurations are comparable in terms of HAI (5 clusters, HAI= 0.83; 6 clusters, HAI=0.81; 7 clusters, HAI=0.84; 8 clusters, HAI=0.84). Based on the overall results, the “5 stock units” is considered the best hypothesis of stock structure of Deep-water pink shrimp.

For the deep water rose shrimp, the configuration with 5 clusters was considered the best candidate. This configuration was characterized by both the highest Cohen’s Kappa and a higher level of acceptability (HAI=0.83). The results, based on 6 biological indicators and 5 thematic layers of information, are considered reliable.

This means that *P. longirostris* populations from GSA's 1, 5, 6 and 7 are considered as a single stock, being extended the limits to the East of Sardinia.

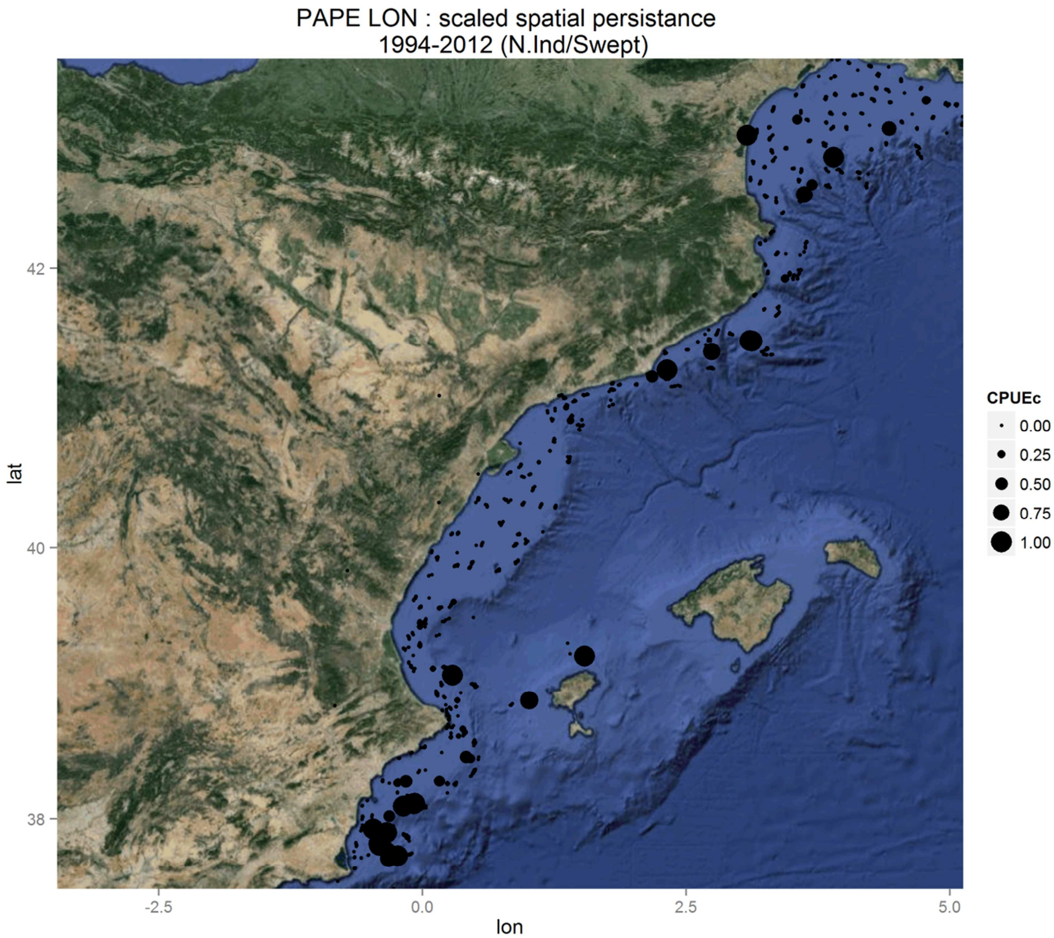


Figure 1.35. Geographical distribution of abundance (nº / km2) and distribution of *Parapenaeus longirostris* in GSA 6 and GSA 7 during MEDITS_ES surveys.

P. longirostris appears to be patchily distributed in the studied areas. Its abundance is noticeable in some areas of the shelf as well as in the shelf-slope break, both in the GSA 6 as in GSA 7.

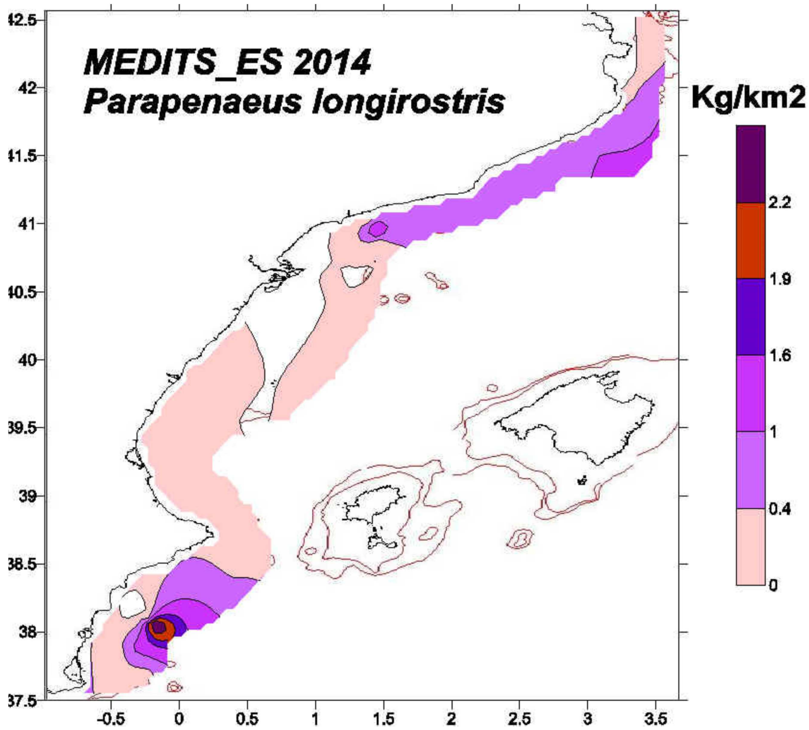


Figure 1.36. Geographical distribution of yields (kg / km2) and distribution of *Parapenaeus longirostris* in GSA 6 during MEDITS_ES 2014 survey.

In the GSA 6, pink shrimp (*P. longirostris)* it is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are some patches located in Santa Pola-Alicante and from Tarragona to the North (Cap de Creus).

Norway Lobster (*Nephrops norvegicus*)

The Norway lobster (*Nephrops norvegicus*) is a demersal species found on muddy bottoms in the North-Eastern Atlantic and the Mediterranean, being common in the coasts of the Iberian Peninsula. It is a sedentary lobster that inhabits borrows built in the mud and is found at depths ranging from 20 to 800 m. This is a target species in fisheries operating at depths of around 400 m. being among the most valuable resources for the trawl fleets in the area (GSA06), with landings reaching an average of 470 t per year (2007-2012) and showing some stability along time. Patchiness of the species populations seems to be related to both heterogeneity in the characteristics of the sediments and variations in fishing effort. There is a relationship between sediment type and depth in the studied area, with the grain size of the sediments decreasing as the distance from the coast increases, so that the finest mud is found in deeper areas.).

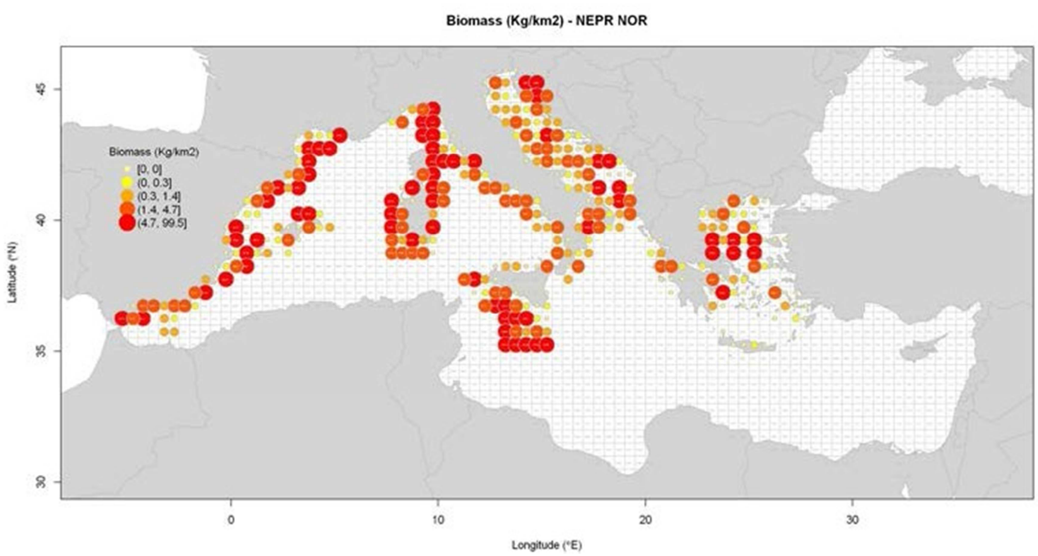


Figure 1.37. Biological indicators (Biomass) from 10 years of MEDITS surveys (2002-2011) for *Nephrops norvegicus.*

Concerning *N.norvegicus*, the CC was performed on six biological indicators (Biomass index, CV % of density, mean fish weight, sex ratio, % of spawning females, median length of spawning females) and the Cohen's Kappa coefficients averaged across four layers of information (Genetics, EFH and connectivity, Density trends, Biomass trends). The mean Cohen's Kappa suggests that the “7 stock units” configuration has the best agreement with the three criteria. The other configurations within the upper quintile are those with 5, 6 and 8 units. According to the acceptability analysis there is weak discrimination between the candidate hypotheses in terms of acceptability for the first rank. However the “8 stock units” presents the highest Holistic Acceptability Index (HAI=0.79) whereas the “7 stock units” has the lower HAI (HAI= 0.66). Based on current information, the “7 stock units” is taken as best ranked hypothesis even if the other configurations deserve high consideration as well. The results are considered plausible, based on currently available information.

This species is one of main fishing resources of the deep-water bottom trawl fleet from the GSA06 area, representing up to 40% in biomass and 30% in economic value (2009-2013 period) from the most important deep-water crustaceans landed (*A. antennatus* and *P. longirostris*). Norway lobster is caught in GSA 6 exclusively by bottom trawlers fishing on the upper slope, between 350-600 m depth. Discards represent lower than 3.5% of the OTB catches in weight. Discards were assumed to be negligible in the present stock assessment.

As regards *N. norvegicus*, two hypotheses were selected from the results of WP4 and further analysed for a last choice. The 7 stock units and the 8 stock units. The former had the higher Cohen’s Kappa coefficient, while the latter had the highest HAI (0.79). Both are quite informative, thus given the better accordance between Cohen’s Kappa and Calinski-Harabasz indices for the 7 units option, this has been selected. Results are considered reliable because based on 6 biological indicators and 4 thematic layers.

This means that *N. norvegicus* populations from GSA’s 1 and 5 on one hand, and 6 and 7 on the other, are considered as two different stocks.

Surveys indices and commercial catches from Medits series indicate a relatively constant exploitation status of Norway lobster. Considering the analitycal approach, the data series is still too short to identify any clear trend in the population parameters.

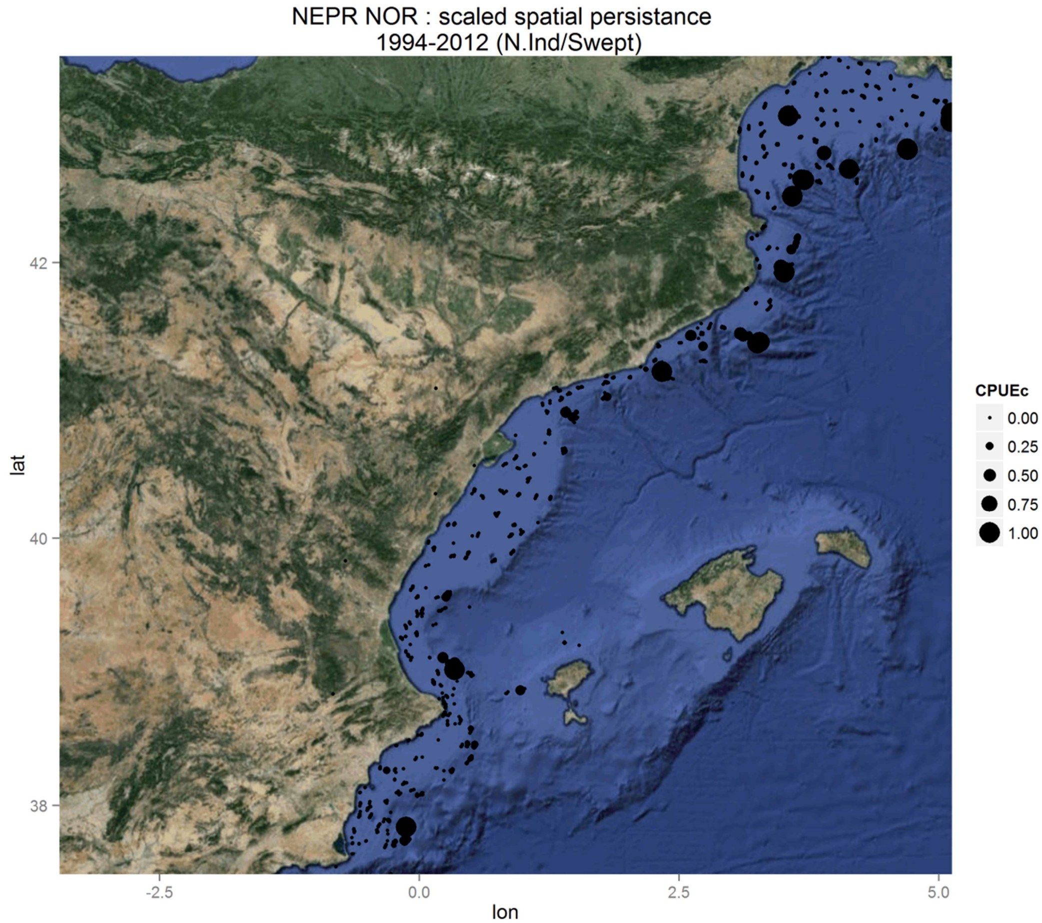


Figure 1.38. Geographical distribution of abundance (nº / km2) and distribution of *Nephrops norvegicus* in GSA 6 and GSA 7 during MEDITS_ES surveys.

N. norvegicus appears to be patchily distributed in the studied areas. Its abundance is noticeable in some areas of the shelf-slope break, both in the GSA 6 as in GSA 7.

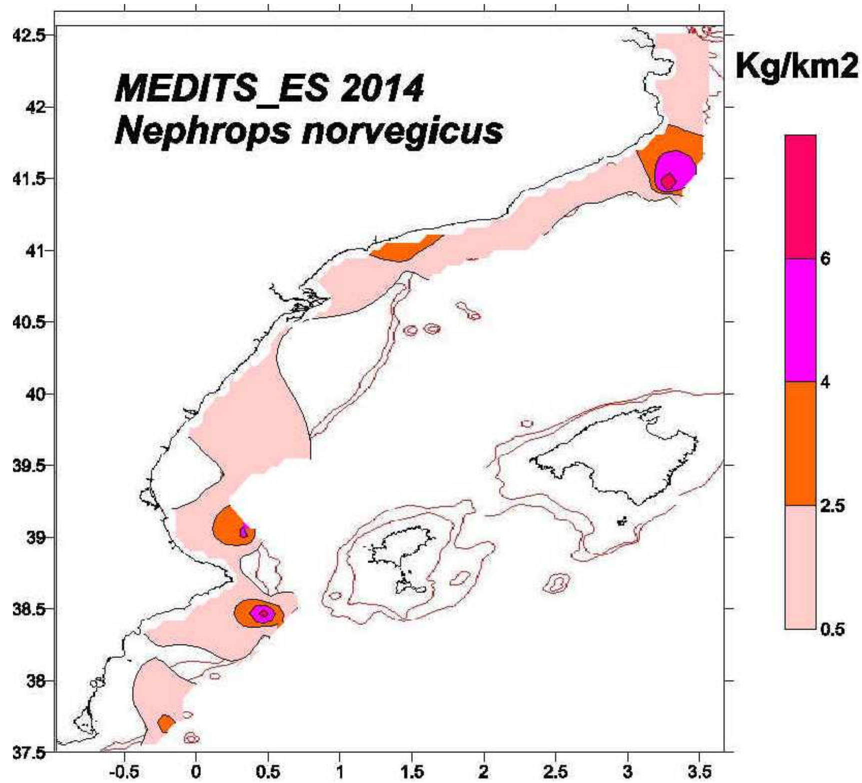


Figure 1.39. Geographical distribution of yields (kg / km2) and distribution of *Nephrops norvegicus* in GSA 6 during MEDITS_ES 2014 survey.

In the GSA 6, Norway lobster (*N. norvegicus)* it is distributed along the entire coast, shelf and mainly in the slope. The areas showing higher values of biomass, according to the yields obtained, are located in front of Mar Menor, North and South of Cape San Antonio and Cap de Creus.

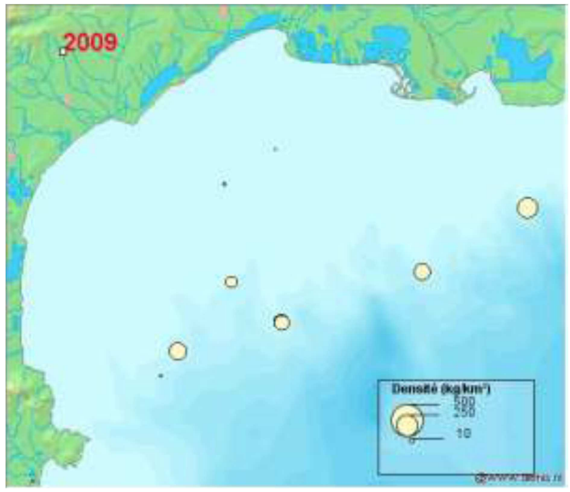
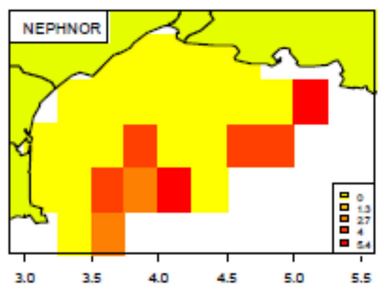


Figure 1.40. Geographical distribution of yields (kg / km2) and distribution of *Nephrops norvegicus* in GSA 7 during 2009.



Red shrimp (*Aristeus antennatus*)

The Red shrimp (*Aristeus antennatus*) is a demersal species that is found on the muddy bottoms of the slope of the continental shelf, more specifically in zones close to the submarine canyons. Its distribution area is very wide, since it is found in the Mediterranean and Atlantic south of the Iberian peninsula, reaching as far as the Portuguese coasts (Arrobas and Ribeiro-Cascalho, 1987).

In the Western Mediterranean (GSA 6 and 7), its bathymetric distribution is wide, between depths of 350 and 800 m. It carries out important migrations of both a diurnal and seasonal character. It not only moves from depths of 200 m during the night to 800 m during the day, but is also able to change its location during the year (Cartes, 1991).

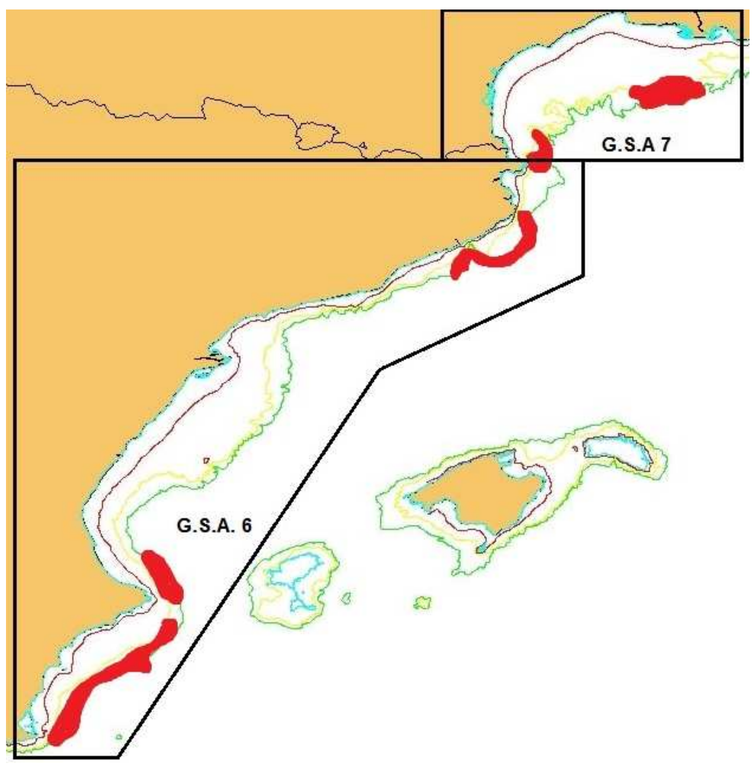


Figure 1.41. Location of the main fishing grounds of *Aristeus antennatus* in both GSAs (6 and 7).

Trawl fleets fishing effort in the ports were quite stable for the period studied with small variations of the number of vessels in the recent years. Vessels length was between 12-24 m. The gears used corresponded to a trawl net 60 and 100 longest rope. The vertical opening was between 1-3 m. The cod end mesh size used was a squared 40 mm of mesh opening. The net was rigged two doors between 500-800 kgs. Trawl fleet in the four ports do daily trips with an unique haul directed to the red shrimp, with a duration between 5-7 hours.

The number of harbours with red shrimp fleets is 22 for the whole area, and the number of boats in this area is 241.

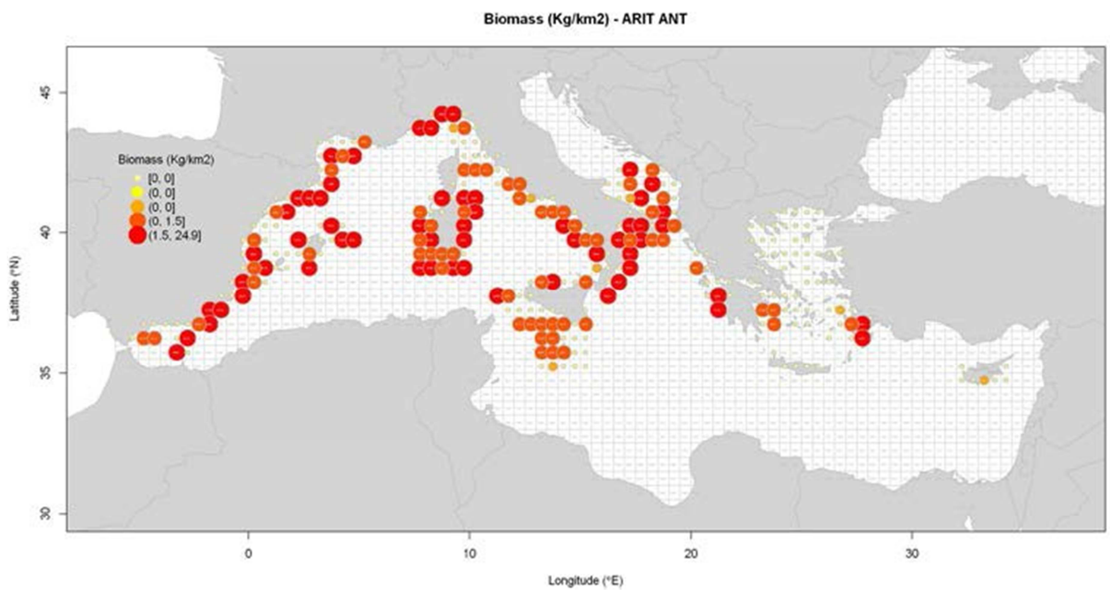


Figure 1.42. Biological indicators (Biomass) from 10 years of MEDITS surveys (2002-2011) for *Aristeus antennatus.*

The stock structure hypotheses for *A.antennatus* were generated through CC performed on six indicators (Biomass index, CV % of density, mean fish weight, sex ratio, % of spawning females, median length of spawning females). The Calinski-Harabasz index shows a decreasing trend with a peak at 4 clusters and other minor peaks at 6 and 8 clusters. The mean Cohen's Kappa, evaluated on five layers of information (Genetics, EFH and connectivity, L50, Growth, Density trends), identifies the "4 stock units" configuration as the hypothesis with the best level of agreement. The upper quintile includes also the configurations with 5, 6 and 8 units. The results of acceptability analysis provide support for these candidate hypotheses as they are the only hypotheses which obtain an acceptability for the first rank (besides the 7 clusters configuration). However, they are comparable in terms of HAI (4 clusters, HAI= 0.87; 5 clusters, HAI= 0.88; 6 clusters, HAI=0.85; 8 clusters, HAI=0.82). According to the currently available information the configuration with 4, 5 and 6 are taken as candidates for the best hypothesis of stock structure. Taking into account the high number of descriptors used in the holistic approach, 6 biological indicators and 5 thematic layers of information, the results are considered plausible.

Regarding blue and red shrimp configurations with 4, 5 and 6 and 8 units had comparable holistic acceptability indices (4 clusters, HAI= 0.87; 5 clusters, HAI= 0.88; 6 clusters, HAI=0.85; 8 clusters, HAI=0.82) though the hypothesis of 4 units had also the higher value of mean Cohen's Kappa, coefficient. Results are considered reliable as based on 6 biological indicators and 5 thematic layers.

In order to compare this configuration with the current GSAs, few rectangles in the GSA7 belonging to the cluster of GSA6 should be instead attributed to the cluster of GSA8 (and other GSAs).

This means that *A. antennatus* populations from GSA's 1, 5, and 6 are considered as a single stock, being extended the limits to the Gulf of Lions (GSA 7).

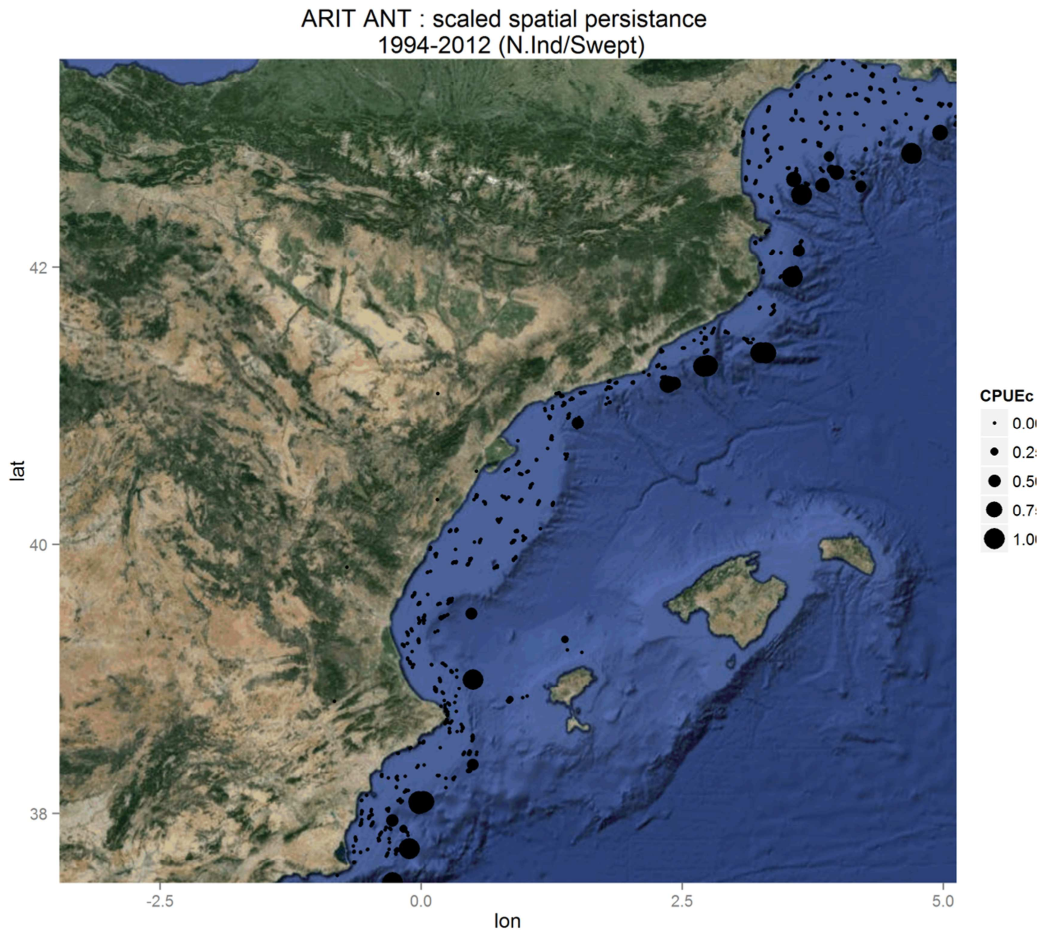


Figure 1.43. Geographical distribution of abundances (nº / km2) and distribution of *Aristeus antennatus* in GSA 6 and GSA 7 during MEDITS_ES surveys.

A. antennatus appears to be patchily distributed in the studied areas. Its abundance is noticeable in some areas of the slope, in areas close to submarine canyons, both in the GSA 6 as in GSA 7.

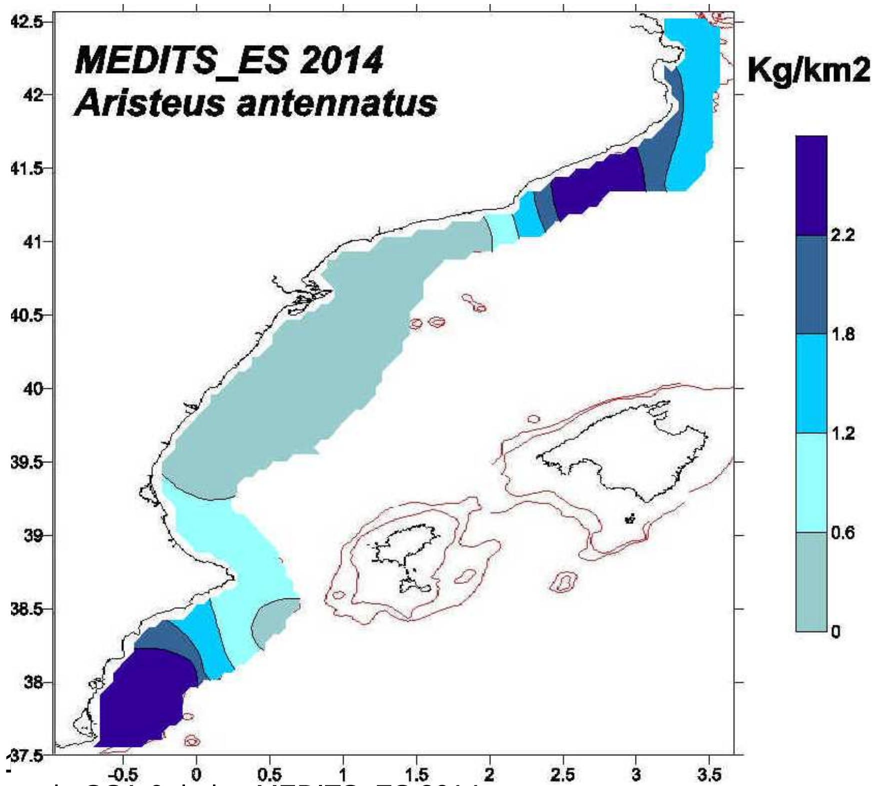


Figure . *Aristeus antennatus* in GSA 6 during MEDITS_ES 2014 survey.

In the GSA 6, red shrimp (*A. antennatus)* it is distributed along the entire coast slope, appearing in areas associated to the presence of submarine canyons. The areas showing higher values of biomass, according to the yields obtained, are located in Mar Menor- Torrevieja, Barcelona-Blanes and Cap de Creus.

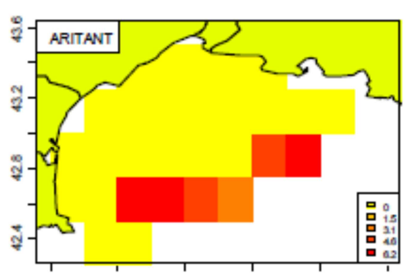


Figure 1.45. Geographical distribution of yields (kg / km2) and distribution of *Aristeus antennatus* in GSA 7 during 2009.

Monkfish (*Lophius budegassa*)

The Genus Lophius LINNEO,1758, has its two species distributed throughout the Mediterranean. The white monk fish *Lophius piscatorius* L. and the black monk fish or sapo, *Lophius budegassa* Spi. are distinguished, among other characteristics, by the different colour of the peritoneum which is white in *L. piscatorius* and black in *L. budegassa*, with both species being considered as purely benthic, since they are distributed from shallow waters down to depths of more than 500 m (Gil de Sola, 1993).

In the Spanish Mediterranean the capture of both monk fish species, by the trawl fleets that operate in the different zones, is frequent and, although they are not considered as a target species of the fisheries, their capture is interesting due to the appreciation that both enjoy in the fish markets.

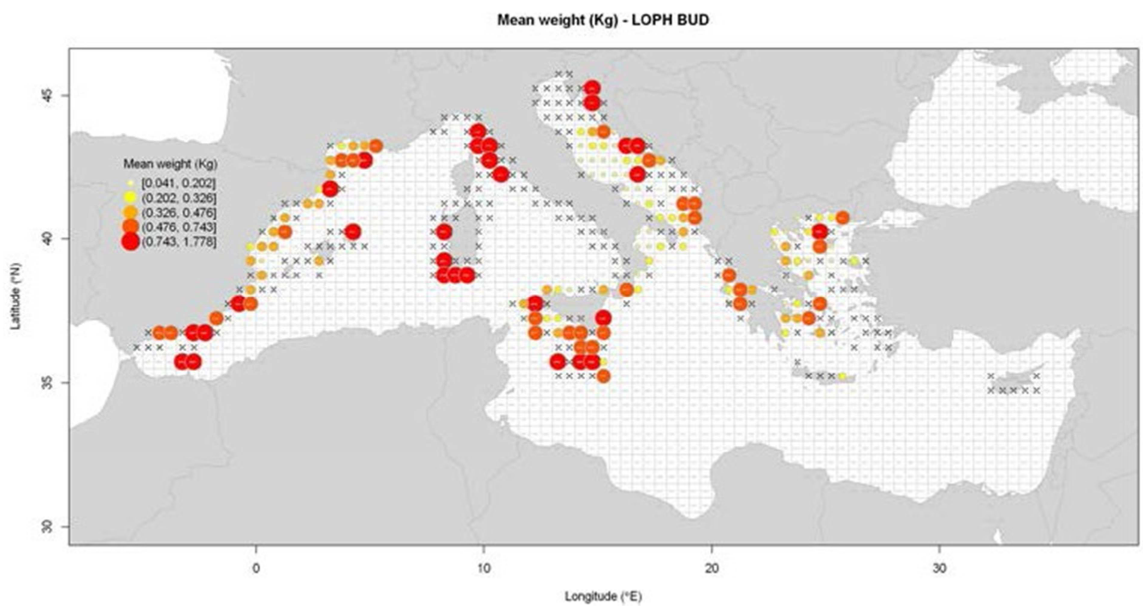


Figure 1.46. Biological indicators (Biomass) from 10 years of MEDITS surveys (2002-2011) for *Lophius budegassa.*

Overall, the stock structure identification of *L.budegassa* was based on three biological indicators (Biomass index, CV % of density, mean fish weight) and two layers of information (Biomass trends and Density trends). The Calinski-Harabasz index has a relative maximum at 6 clusters, whereas the mean

Cohen’s Kappa shows the highest values at 4 and 5 clusters. One other hypothesis included in the upper quintile is the 10 clusters configuration. According to the acceptability analysis, the only hypothesis that attains an acceptability for the first rank is the “4 stock units” configuration (HAI=1).

The configurations with 5 and 10 clusters respectively, attain acceptability for the second rank but the 10 clusters configuration has the highest HAI (0.92 against 0.83). According to these results the “4 stock units” configuration represents the best hypothesis of stock structure. However, considering that the analysis was based on few strata of information (3 biological indicators and 2 thematic layers of information), the proposed stock structure should be considered as provisional.

According with the results reported in D15 the two configurations with higher probability were the 4 stock units configuration which gained a HAI=1 and the 10 clusters configuration with a HAI=0.92. However the Cohen’s Kappa coefficient of the 4 stock units configuration was the higher and this configuration was also in the first rank of acceptability. However, considering that the analysis was based on few strata of information (3 biological indicators, i.e. inverse of density CV, biomass index and mean weight which were considered less powerful by the expert panel) and 2 thematic layers, the proposed stock structure should be considered as provisional. Thus the communication table is not provided.

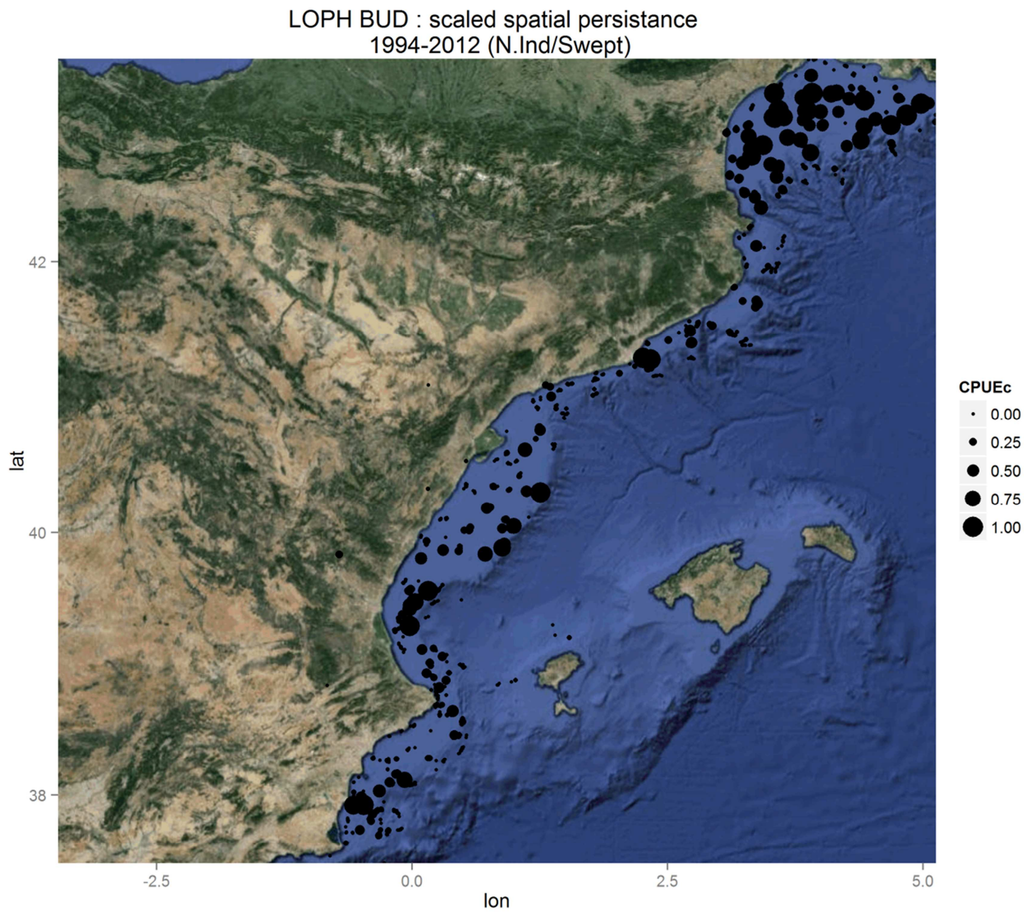


Figure 1.47. Geographical distribution of abundances (nº / km2) and distribution of *Lophius budegassa* in GSA 6 and GSA 7 during MEDITS_ES surveys.

L. budegassa appears to be widely distributed in the studied areas. Its abundance is noticeable in some areas of the shelf as well as in the shelf-slope break, both in the GSA 6 as in GSA 7.

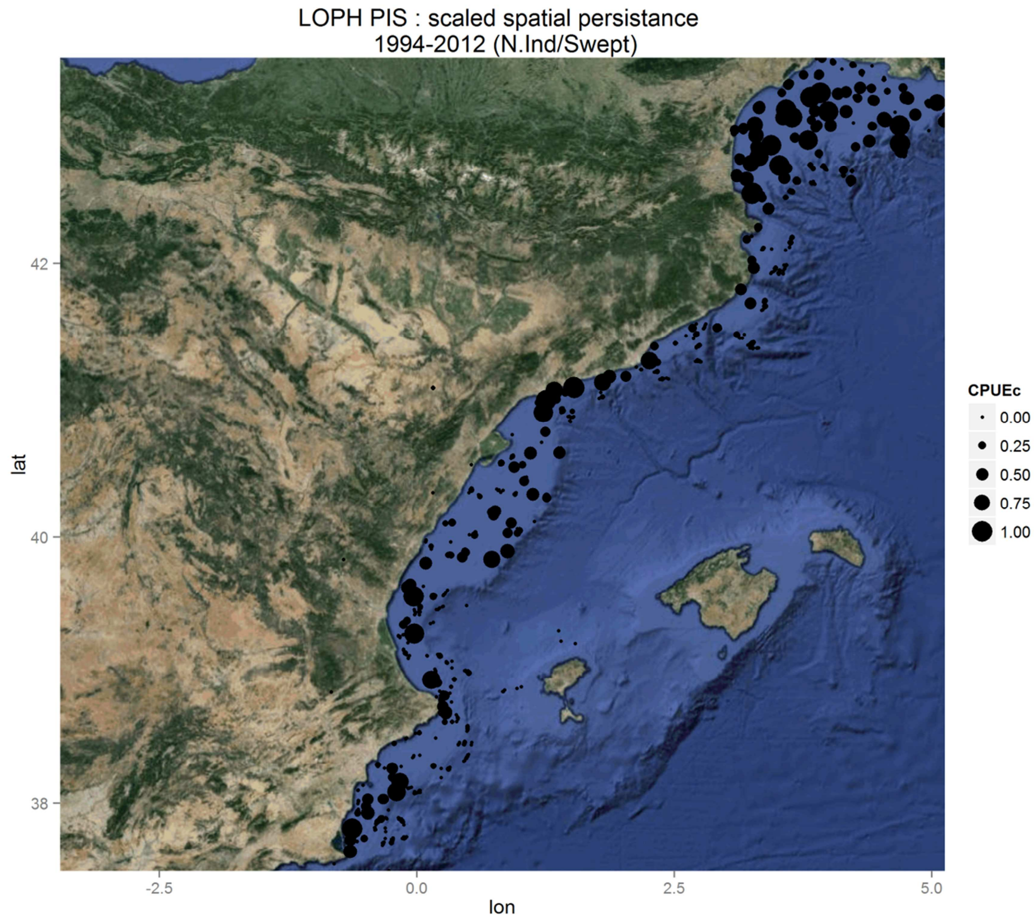


Figure 1.48. Geographical distribution of abundances (nº / km2) and distribution of *Lophius piscatorius* in GSA 6 and GSA 7 during MEDITS_ES surveys.

L. piscatorius appears to be widely distributed in the studied areas. Its abundance is noticeable in some areas of the shelf as well as in the shelf-slope break, both in the GSA 6 as in GSA 7, were is specially abundant.

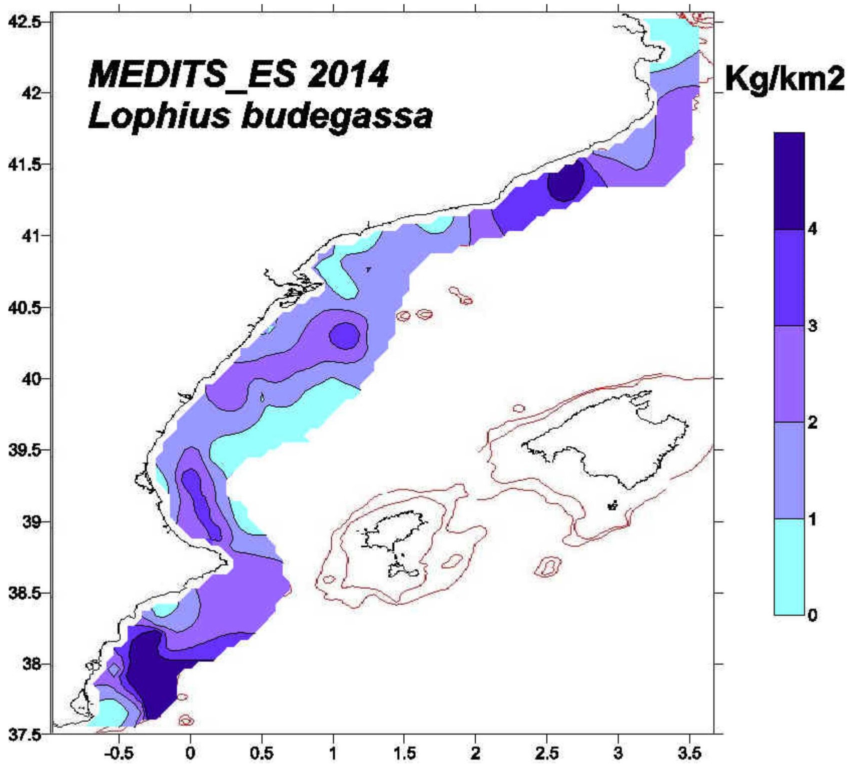


Figure 1.49. Geographical distribution of yields (kg / km2) and distribution of *Lophius budegassa* in GSA 6 during MEDITS_ES 2014 survey.

In the GSA 6, monkfish (*L. budegassa)* it is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are located in Santa Pola-Alicante, South of the Gulf of Valencia, South of Ebro River, Blanes and Cap de Creus.

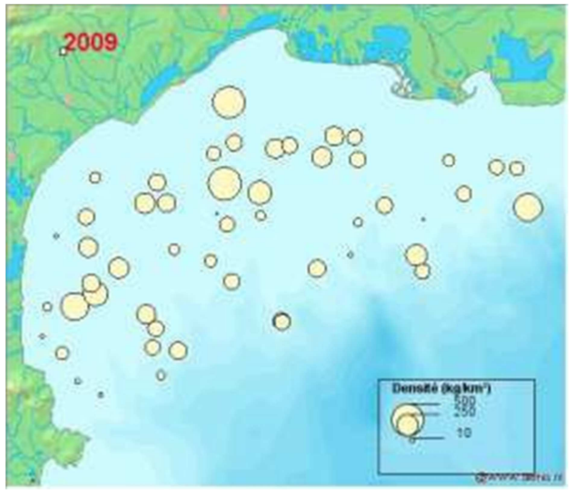


Figure 1.50. Geographical distribution of yields (kg / km2) and distribution of *Lophius budegassa* in GSA 7 during 2009.

Others stocks

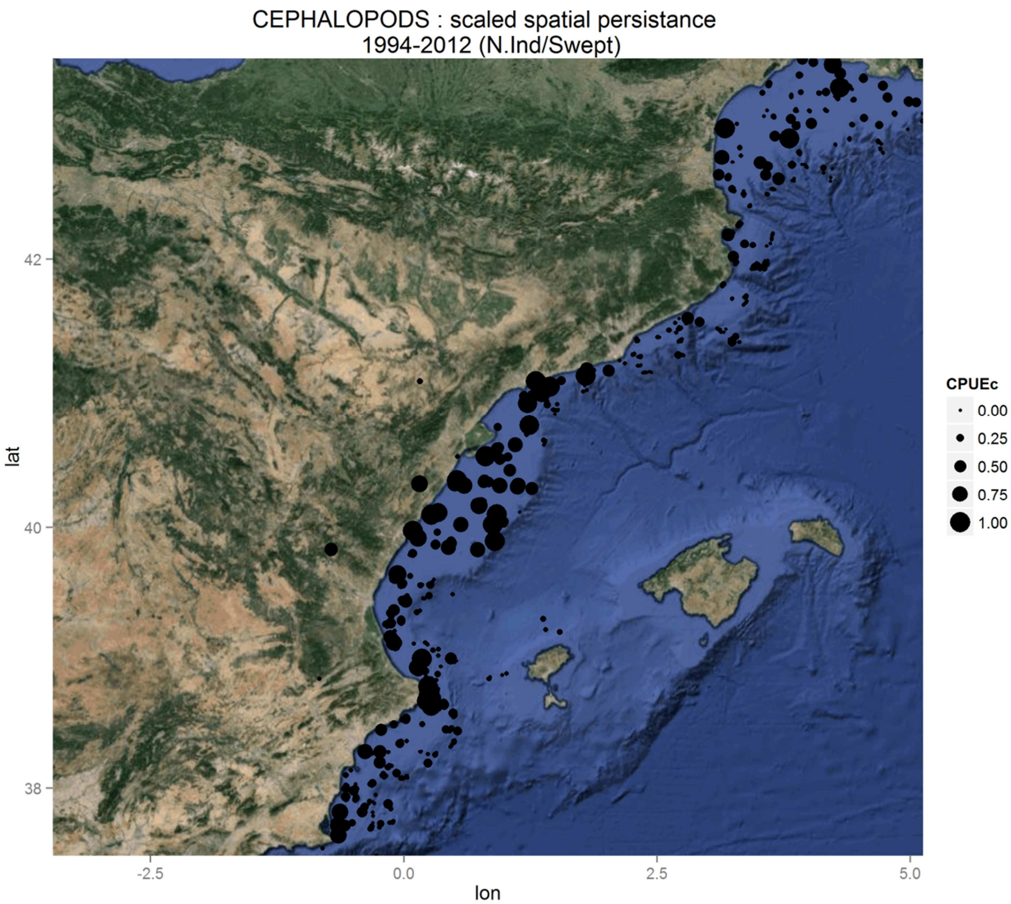


Figure 1.51. Geographical distribution of abundances (nº / km2) and distribution of *cephalopods* in GSA 6 and GSA 7 during MEDITS_ES surveys.

Cephalopods appear to be widely and uniformly distributed in the studied areas. Its abundance is noticeable along the shelf, both in the GSA 6 as in GSA 7.

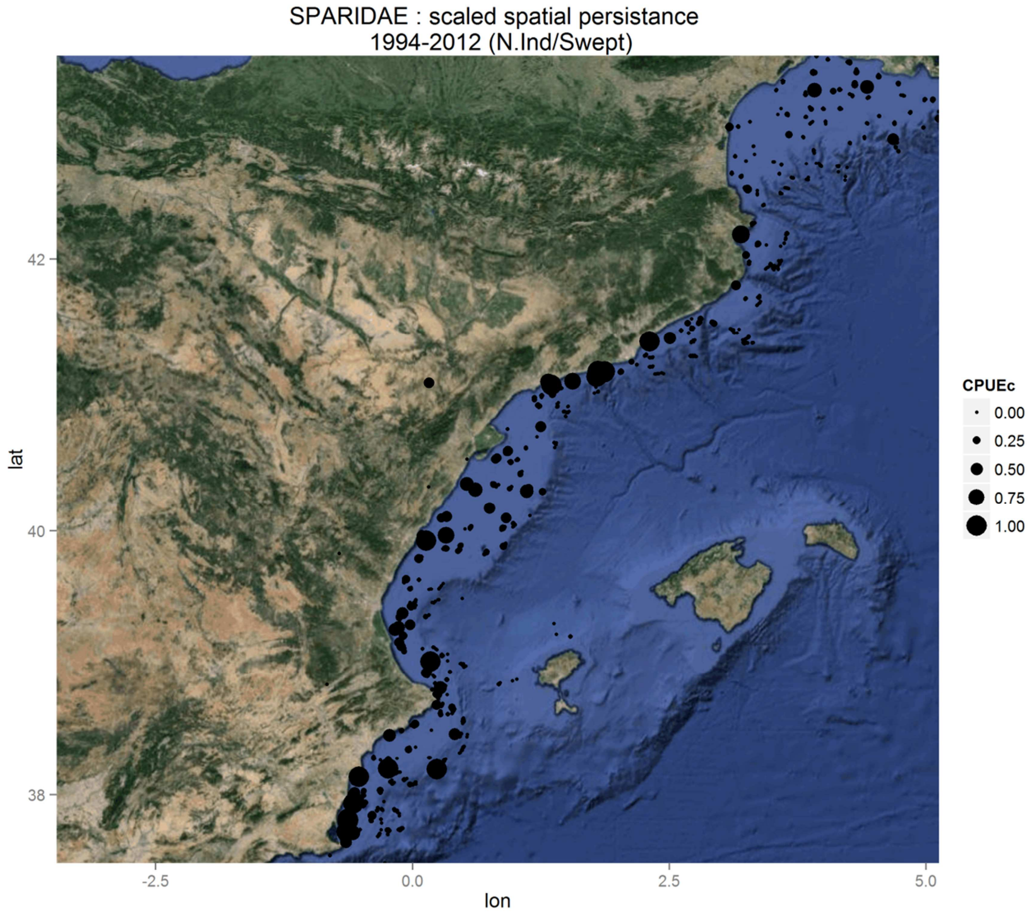


Figure 1.52. Geographical distribution of abundances (nº / km2) and distribution of *Sparidae* in GSA 6 and GSA 7 during MEDITS_ES surveys.

Sparidae appear to be widely distributed in the studied areas. Its abundance is noticeable along the coast and the shelf, both in the GSA 6 as in GSA 7, being more abundant in the GSA 6.

SPATIAL COVERAGE: CONCLUSIONS

Benthic and demersal species are exploited by the semi-industrial trawler fleets as well as artisanal vessels. Artisanal fisheries are characterized by high diversity of species caught and by the absence of large monospecific stocks. Although the number of artisanal vessels is important in some areas with high social impact, catches account for only a very small part of the total. Most of the landings of demersal species come from the bottom trawl fleets. The multispecies nature of the bottom trawl fishery is evident if we consider that catches can eventually identify more than 600 species from different taxonomic groups. Consequently, the proportion of discards is very high, up to 77% of species and 30-40% of the total weight caught. The exploitation extends to both the platform and the continental slope; the predominant species at landings vary with depth.

The Gulf of Lions supports fisheries that include bottom and pelagic trawls, purse seines, gill nets and longlines, and is furthermore an important spawning area for many pelagic and demersal species. The demersal fisheries are multi-species and multi-gears fisheries. The marine living resources of the Gulf of Lions are a “shared stock” which is essentially exploited by French and Spanish fishing boats. The main part of the fishing grounds exploited by these boats cover the entire continental shelf from the coastline to the 200 metres isobath, with an area of some 14 000 square kilometres covered by sandy deposits.

Species are widely distributed along the Mediterranean coasts, covering all GSAs. Referring to the biomass index, the pair of contiguous GSAs with highest amount of time series of species correlated was the Gulf of Lions (GSA 7) and Corsica (GSA 8) with 7species significantly correlated, while two additional pairs showed 5 species with significantly correlated time series, i.e. Northern Alboran Sea (GSA 1) and Northern Spain (GSA 6), Northern Spain (GSA 6) and Gulf of Lions (GSA 7).

M. merluccius populations from GSA’s 1, 5, 6 and 7 are considered as a single stock. In the GSA 6 is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are located in Cabo de Palos, Gulf of Valencia, Columbretes Islands, Badalona, Blanes and Cap de Creus. In GSA 7, The hake is a species very widely distributed in the Gulf of Lions since the very coastal sector, near 30m depth, until 800 m. The species is mainly present between 80 and 150 m.

M. barbatus occurs on sandy and muddy bottoms between 50 and 200m depth in areas with wider continental shelf, whereas *M. surmuletus* has a wider bathymetric range (occurring to a depth of 400 m) but its maximum abundance is concentrated near the coast, on gravel and rocky bottoms between 10 and 100m depth, especially in areas where the shelf is steepest and with a higher influence of seagrass beds, especially *Posidonia oceanica*. *M. barbatus* populations from GSA's 1,5, 6 and 7 are considered as a single stock, being extended the limits to the Western Ionian Sea. In the GSA 6, mullet (*M. barbatus*) it is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are located in Cape de Palos, South of the Gulf of Valencia, Columbretes Islands and Blanes-Cap de Creus.

M. surmuletus populations from GSA's 1, 5, and 6 are considered as a single stock, being extended the limits to the Gulf of Lions (GSA 7). In the GSA 6, red mullet (*M. surmuletus)* it is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are located in Santa Pola-Alicante, South of the Gulf of Valencia, in front of Valencia-Sagunto, Columbretes Islands, Barcelona and Blanes.

P. longirostris populations from GSA's 1, 5, 6 and 7 are considered as a single stock, being extended the limits to the East of Sardinia. Deepwater pink shrimp is distributed from 150 to 400 m depth in GSA 06, with higher densities on soft muddy bottoms in the southern part of GSA and, in years of high abundance of the population also in the north of GSA 06. The areas showing higher values of biomass, according to the yields obtained, are located in Santa Pola-Alicante and from Tarragona to the North (Cap de Creus).

The Norway lobster (*Nephrops norvegicus*) is a demersal species found on muddy bottoms along the coasts of the Iberian Peninsula. It is a sedentary lobster that inhabits borrows built in the mud and is found at depths ranging from 20 to 800 m. *N. norvegicus* populations from GSA's 1 and 5 on one hand, and 6 and 7 on the other, are considered as two different stocks. In the GSA 6, In GSA 6, Norway lobster it is distributed along the entire coast, shelf and mainly in the slope. The areas showing higher values of biomass, according to the yields obtained, are located in front of Mar Menor, North and South of Cape San Antonio and Cap de Creus.

The Red shrimp (*Aristeus antennatus*) is a demersal species that is found on the muddy bottoms of the slope of the continental shelf, more specifically in zones close to the submarine canyons. Its distribution area is very wide, since it is found in the Mediterranean and Atlantic south of the Iberian peninsula. In the Western Mediterranean (GSA 6 and 7), its bathymetric distribution is wide, being found between depths of 350 and 800 m. *A. antennatus* populations from GSA's 1, 5, and 6 are considered as a single stock, being extended the limits to the Gulf of Lions (GSA 7). In the GSA 6, red shrimp it is distributed along the entire coast slope, appearing in areas associated to the presence of submarine canyons. The areas showing higher values of biomass, according to the yields obtained, are located in Mar Menor- Torrevieja, Barcelona-Blanes and Cap de Creus.

The Genus Lophius LINNEO,1758, has its two species distributed throughout the Mediterranean. The white monk fish *Lophius piscatorius* L. and the black monk fish, *Lophius budegassa* Spi. with both species being considered as purely benthic, since they are distributed from shallow waters down to depths of more than 500 m. In the GSA 6, monkfish (*L. budegassa)* it is distributed along the entire coast, shelf and slope. The areas showing higher values of biomass, according to the yields obtained, are located in Santa Pola-Alicante, South of the Gulf of Valencia, South of Ebro River, Blanes and Cap de Creus.

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SOCIO-ECONOMIC INDICATORS

Country	France	France	France	France	France	Spain	Spain	Spain	Spain	Spain
Main gear	DTS	DTS	DTS	DFN	DFN	DTS	DTS	DTS	HOK	HOK
Vessel length	VL1218	VL1824	VL2440	VL0612	VL1218	VL1218	VL1824	VL2440	VL0612	VL1218
Total number of vessels		28	32	404	9	164	346	155	80	90
Total landing share in the area	0.10%	2.80%	4.20%	1.50%	0.10%	6.00%	21.10%	12.80%	1.00%	3.00%
Target landing share in the area	0.10%	2.00%	3.30%	0.40%	0.00%	9.00%	**45.90%**	**34.00%**	0.20%	0.10%
Target species importance in fleet's turnover	**14.00%**	**21.50%**	**23.50%**	6.00%	3.60%	**26.30%**	**44.20%**	**61.70%**	5.20%	1.60%
Totals weight of landings (tonnes)	24	2333	4416	735	35	4746	12296	6399	107	545
value of landings (landings' Income) (M €)	0.2	9	13.5	4.7	0.3	19	67.4	40.9	3.3	9.5
Total fishers employed		84	149	444	26	383	1499	736	223	360
FTE harmonised (1)		71	111	273	12	300	1605	567	124	216
Fishers per vessel		3	4.7	1.1	2.9	2.3	4.3	4.8	2.8	4
Operating GVA per vessel (000 €) (2)		94.9	104.4	14.4	56.4	60.2	62.8	78.7	12.3	58.6
Total wages and salaries of crew including unpaid labour (M €) (3)		2.8	4.6	6.8	0.5	8.5	22.9	13.2	2.2	3.4
Operating EBIT per vessel (000 €) (4)		-3.7	-38.1	-2.5	2.3	8.2	-3.2	-7	-14.8	21.3

(1) Full-time equivalent (FTE) or whole time equivalent (WTE) is a unit that indicates the workload of an employed person in a way that makes workloads or class loads comparable across various contexts. An FTE of 1.0 is equivalent to a full-time worker, while an FTE of 0.5 signals half of a full work.

(2) Gross value added (GVA) is a measure of the value of goods produced in an area, industry or sector of an economy. Operating Gross Value Added = Value of landings (landings' Income) - (Energy costs + Other non-variable costs + Other variable costs + Repair & maintenance costs + Annual depreciation costs).

(3) Wages and salaries of crew + Unpaid labour value.

(4) EBIT or operating profit is the profit earned from a firm's normal core business operations. This value does not include any profit earned from the firm's investments (such as earnings from firms in which the company has partial interest) and the effects of interest and taxes. Operating EBIT = Value of landings (landings' Income) - (Energy costs + Wages and salaries of crew + Unpaid labour value + Other non-variable costs + Other variable costs + Repair & maintenance costs + Annual depreciation costs).

				Value of landings							Fleet landings value share on total area landings value							Dependency degre: Importance of target species in the fleet revenues					
Country	Gear	Length	Fishers employed	ARA	DPS	HKE	MUX	WHB	Target landings	Total landings	Total share	Target spp sl	ARA share	DPS share	HKE share	MUX share	WHB share	Total share	ARA share	DPS share	HKE share	MUX share	WHB share
France	DFN	VL0006	74			155	4710		4865	889418	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.5	0.0
France	DFN	VL0612	444		47	130774	150463	1284	282567	4709251	1.5	0.4	0.0	0.0	0.6	1.3	0.0	6.0	0.0	0.0	2.8	3.2	0.0
France	DFN	VL1218	26			10306	602		10908	299934	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0	3.4	0.2	0.0
France	DRB	VL0006							0	27141	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
France	DRB	VL0612	7			20	1342		1362	21197	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4	0.0	0.0	0.1	6.3	0.0
France	DTS	VL1218			14944	4872	6844	2154	28813	206048	0.1	0.1	0.0	0.4	0.0	0.1	0.1	14.0	0.0	7.3	2.4	3.3	1.0
France	DTS	VL1824	84		9916	1561056	364424	4106	1939502	9009702	2.8	2.0	0.0	0.3	6.7	3.1	0.1	21.5	0.0	0.1	17.3	4.0	0.0
France	DTS	VL2440	149		6782	2607393	549362	8438	3171975	13515307	4.2	3.3	0.0	0.2	11.2	4.7	0.3	23.5	0.0	0.1	19.3	4.1	0.1
France	FPO	VL0006	73		70		3423		3494	1347898	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.0
France	FPO	VL0612	53		102	296	18628		19026	1734592	0.5	0.0	0.0	0.0	0.0	0.2	0.0	1.1	0.0	0.0	0.0	1.1	0.0
France	FPO	VL1218				1039	138		1177	44250	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	2.3	0.3	0.0
France	HOK	VL0006	10						0	103343	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
France	HOK	VL0612	57			551	2951		3503	613824	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.1	0.5	0.0
France	HOK	VL1218							0	113043	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
France	MGO	VL0612	24				14427		14427	109398	0.0	0.0	0.0	0.0	0.0	0.1	0.0	13.2	0.0	0.0	0.0	13.2	0.0
France	PGO	VL0006	46						0	378532	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
France	PGO	VL0612	67		63		1313		1376	150846	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.9	0.0
France	PGP	VL0006	61		18	117	1761		1896	1336642	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
France	PGP	VL0612	107		2	18171	29082		47254	2530778	0.8	0.1	0.0	0.0	0.1	0.2	0.0	1.9	0.0	0.0	0.7	1.1	0.0
France	PGP	VL1218				60216	201		60417	235177	0.1	0.1	0.0	0.0	0.3	0.0	0.0	25.7	0.0	0.0	25.6	0.1	0.0
France	PMP	VL0006					2633		2633	15588	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.9	0.0	0.0	0.0	16.9	0.0
France	PMP	VL0612	31			2351	2452		4803	779094	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.3	0.3	0.0
France	PMP	VL1218				9			9	152780	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
France	PS	VL0612	37				3381		3381	793690	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4	0.0
France	PS	VL1218	59				1135		1135	608012	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.0
France	PS	VL1824					6		6	652699	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
France	PS	VL2440	82						0	7032317	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
France	PS	VL40XX							0	2308994	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
France	TM	VL2440			26	137152	15909	86	153173	2286397	0.7	0.1	0.0	0.0	0.6	0.1	0.0	6.7	0.0	0.0	6.0	0.7	0.0
Total French			1489	0	31970	4534477	1175186	16067	5757701	52005893	16.3	6.2	0.0	0.9	19.4	10.0	0.5	11.1	0.0	0.1	8.7	2.3	0.0

Country	Gear	Length		ARA	DPS	HKE	MUX	WHB	Target landings	Total landings	Total share	Target spp sl	ARA share	DPS share	HKE share	MUX share	WHB share	Total share	ARA share	DPS share	HKE share	MUX share	WHB share
Spain	DFN	VL0612	200		140	138090	199912	46	338188	4435237	1.4	0.5	0.0	0.0	0.6	1.7	0.0	7.6	0.0	0.0	3.1	4.5	0.0
Spain	DFN	VL1218	178		93	211628	205098	28	416846	3147749	1.0	0.5	0.0	0.0	0.9	1.7	0.0	13.2	0.0	0.0	6.7	6.5	0.0
Spain	DFN	VL1824				182	0		182	2966	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	0.0	0.0	6.2	0.0	0.0
Spain	DRB	VL0006					0		0	36885	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spain	DRB	VL0612	92			109	4402		4510	793758	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.6	0.0
Spain	DRB	VL1218	39	8760		1726	0	157	10643	601358	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.8	1.5	0.0	0.3	0.0	0.0
Spain	DTS	VL0006					0		0	9592	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spain	DTS	VL0612	61	19556	3344	57140	117747	9530	207317	1420445	0.4	0.3	0.1	0.1	0.2	1.0	0.3	14.6	1.4	0.2	4.0	8.3	0.7
Spain	DTS	VL1218	383	680165	536580	1670534	2055803	76088	5019170	19090225	6.0	9.0	2.5	15.2	7.2	17.4	2.6	26.3	3.6	2.8	8.8	10.8	0.4
Spain	DTS	VL1824	1499	13105862	2190197	8771868	4375506	1356656	29800088	67356443	21.1	45.9	47.3	62.1	37.6	37.1	45.5	44.2	19.5	3.3	13.0	6.5	2.0
Spain	DTS	VL2440	736	13810688	759145	7120006	1994887	1521243	25205969	40855057	12.8	34.0	49.9	21.5	30.5	16.9	51.0	61.7	33.8	1.9	17.4	4.9	3.7
Spain	FPO	VL0612	57			4470	29402		33872	785840	0.2	0.1	0.0	0.0	0.0	0.2	0.0	4.3	0.0	0.0	0.6	3.7	0.0
Spain	FPO	VL1218	90			2725	147		2872	760579	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.4	0.0	0.0
Spain	FPO	VL2440					0		0	2768698	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spain	HOK	VL0006					24		24	5518	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4	0.0
Spain	HOK	VL0612	223	78		158375	14266	709	173427	3315694	1.0	0.2	0.0	0.0	0.7	0.1	0.0	5.2	0.0	0.0	4.8	0.4	0.0
Spain	HOK	VL1218	360		1294	143287	8804	188	153572	9533976	3.0	0.1	0.0	0.0	0.6	0.1	0.0	1.6	0.0	0.0	1.5	0.1	0.0
Spain	HOK	VL1824	195			134	0	46	180	6562325	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spain	HOK	VL2440					0		0	1765922	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spain	PGP	VL0006	161			2179	62524		64704	1377827	0.4	0.1	0.0	0.0	0.0	0.5	0.0	4.7	0.0	0.0	0.2	4.5	0.0
Spain	PGP	VL0612	1888	25221	590	483284	1545965	471	2055532	23840878	7.5	3.1	0.1	0.0	2.1	13.1	0.0	8.6	0.1	0.0	2.0	6.5	0.0
Spain	PGP	VL1218	42			43324	7128		50453	1071904	0.3	0.0	0.0	0.0	0.2	0.1	0.0	4.7	0.0	0.0	4.0	0.7	0.0
Spain	PS	VL0006					0		0	32278	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spain	PS	VL0612	109			189	1929		2118	2458030	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Spain	PS	VL1218	767		2643	5006	2422	76	10147	21842622	6.8	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spain	PS	VL1824	930	3877		3885	5721	76	13558	33016105	10.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spain	PS	VL2440	303	25844			0	152	25996	13283695	4.2	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0
Spain	PS	VL40XX					0		0	7090698	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Spanish			8312	27680051	3494026	18818141	10631686	2965465	63589369	267262303	84	93.8	100.0	99.1	80.6	90.0	99.5	23.8	10.4	1.3	7.0	4.0	1.1
Total in area			9801	27680051	3525996	23352619	11806872	2981532	69347070	319268196	100												

```
###############################################################################
#   ANNEX IV - MSE CODE
###############################################################################


###############################################################################
# EJ(20150610-20150703) JRC, IPSC, MAU <ernesto.jardim@jrc.ec.europa.eu>
# MSE to test the options given by MARE to EWG1509 - NWMed MAP
# Based on FLR (http://flr-project.org)
# and a4a (https://fishreg.jrc.ec.europa.eu/web/a4a)
###############################################################################
# IMPORTANT
# This code is made avaibale under a creative commons license BY-SA 4.0
# (http://creativecommons.org/licenses/by-sa/4.0/)
###############################################################################

#==============================================================================
# NOTE: The first intermediate year must be the last on the assessment so that
#   the OM has information for the MPs assessment/intermediate year.
#==============================================================================

#==============================================================================
# libraries and constants
#==============================================================================
library(FLa4a)
library(FLash)
library(FLBRP)
library(FLAssess)
library(FLXSA)
library(ggplotFL)
source("funs.R")

#==============================================================================
# Read data
#==============================================================================

load("../../data/HKESA07.RData")
attach("../../data/HKESA07_idx.RData")
idx <- hke.idx[[1]]
detach()

#==============================================================================
# Setup
#==============================================================================

# stock
range(stk)[c("minfbar", "maxfbar")] <- c(0,1)
catch.n(stk) <- landings.n(stk)

# fixed variables
it <- 250
amx <- range(stk)["max"]
y0 <- range(stk)["minyear"] # initial data year
# data year, assessment year and initial projections year (also intermediate)
dy <- ay <- iy <- range(stk)["maxyear"]
ny <- 24 # number of years to project
fy <- iy + ny -1 # final year
vy <- ac(iy:fy) # year vector for projections
nsqy <- 3 # number of years to compute status quo metrics
trgy <- 2015

#==============================================================================
# Conditioning
#==============================================================================

catch.n(stk)[catch.n(stk)==0] <- 0.01
index(idx)[index(idx)==0] <- 0.01
fit <- sca(stk, FLIndices(idx), fit="assessment", fmodel=~s(age, k=5) + s(year, k=10))
stk <- stk + fit
sstk <- stk + simulate(fit, it)
```

```
pstk <- stf(sstk, ny, 5, 5)
landings.n(pstk) <- propagate(landings.n(pstk), it)
discards.n(pstk) <- propagate(discards.n(pstk), it)

#-------------------------------------------------------------------------------
# S/R
#-------------------------------------------------------------------------------
sr <- fmle(as.FLSR(stk, model="geomean")) # bevholt, ricker

#-------------------------------------------------------------------------------
# BRP
#-------------------------------------------------------------------------------
rp <- brp(FLBRP(stk, sr))

#-------------------------------------------------------------------------------
# S/R residuals
#-------------------------------------------------------------------------------
sr.res <- window(rec(pstk), iy, fy)
sr.res[] <- sample(c(residuals(sr)), ny*it, replace=TRUE)

#-------------------------------------------------------------------------------
# index (pulled to 1st of January)
#-------------------------------------------------------------------------------
lst <- mcf(list(idx@index, stock.n(stk)))
idx.lq <- log(lst[[1]]/lst[[2]])
idx.lq[is.infinite(idx.lq)] <- NA # fix zeros
idx.qmu <- idx.qsig <- stock.n(iter(pstk,1))
idx.qmu[] <- yearMeans(idx.lq)
idx.qsig[] <- log((sqrt(yearVars(idx.lq))/yearMeans(idx.lq))^2 + 1)
idx.q <- idx <- FLQuant(NA, dimnames=dimnames(stock.n(pstk)))
idx.q[,ac(y0:dy)] <- propagate(exp(idx.lq[,ac(y0:dy)]), it)
idx.q[!is.na(idx.qmu)] <- rlnorm(it, idx.qmu[!is.na(idx.qmu)], idx.qsig[!is.na(idx.qmu)])
plot(idx.q)
idx <- idx.q * stock.n(pstk)
idx <- FLIndex(index=idx, index.q=idx.q)
range(idx)[c("startf", "endf")] <- c(0, 0)
plot(index(idx))

#===============================================================================
# Management scenarios
#===============================================================================
#fmsy <- refpts(rp)["msy","harvest"]
#fmsy <- refpts(rp)["f0.1","harvest"]
fmsy <- 0.20
blim <- min(ssb(stk))
bpa <- blim*1.4
fupp <- 0.007801555 + 1.349401721*fmsy
flow <- 0.00296635 + 0.66021447*fmsy

#===============================================================================
# Projections
#===============================================================================

ftrg <- mean(fbar(stk)[,ac(2011:2013)])
#ftrg <- mean(fbar(stk))
perfstats <- harvest(pstk)
perfstats[] <- NA
dt <- date()
sa <- list()

# go fish
for(i in vy[-length(vy)]){
    gc()
    ay <- an(i)
    cat(i, " > ")
    vy0 <- 1:(ay-y0) # data years (positions vector)
    sqy <- (ay-y0-nsqy+1):(ay-y0) # status quo years (positions vector)
    stk0 <- pstk[,vy0]
    # change M before assessing
    catch.n(stk0) <- catch.n(stk0) + 1 # avoid zeros
```

```
    idx0 <- idx[,vy0]
    index(idx)[,i] <- stock.n(pstk)[,i]*index.q(idx)[,i]
    fit0 <- sca(stk0, FLIndices(idx0), fmodel=~factor(age) + factor(year))
    stk0 <- stk0 + fit0
    # fwd control
    fsq0 <- yearMeans(fbar(stk0)[,sqy])
    dnms <- list(iter=1:it, year=c(ay, ay+1), c("min", "val", "max"))
    arr0 <- array(NA, dimnames=dnms, dim=unlist(lapply(dnms, length)))
    ftrg0 <- fsq0 - (fsq0-ftrg)/ifelse(trgy - ay < 1, 1, trgy - ay)
    arr0[,,"val"] <- c(fsq0, ftrg0)
    arr0 <- aperm(arr0, c(2,3,1))
    ctrl <- fwdControl(data.frame(year=c(ay,ay+1), quantity="f", val=NA))
    ctrl@trgtArray <- arr0
    #stkTmp <- stf(stk0, 3)
    #stkTmp <- fwd(stkTmp, ctrl=ctrl, sr=sr, sr.residuals = exp(sr.res[,ac(ay:(ay+1))]), sr.residuals.mult = TRUE)

    # OM proj
    ctrl@target <- ctrl@target[2,]
    ctrl@trgtArray <- ctrl@trgtArray[2,,,drop=FALSE]
    ctrl@target["rel.year"] <- ay-1
    perfstats[1,ac(ay-1)] <- fbar(pstk)[,ac(ay-1)]
    perfstats[2,ac(ay-1)] <- fbar(stk0)[,ac(ay-1)]
    perfstats[3,ac(ay-1)] <- fsq0
    perfstats[4,ac(ay+1)] <- ftrg0
    # until 2015 keep fsq
    if(ay<2015) ctrl@trgtArray[,"val",] <- 1 else ctrl@trgtArray[,"val",] <- c(ftrg0)/c(fsq0)

    pstk <- fwd(pstk, ctrl=ctrl, sr=sr, sr.residuals = exp(sr.res[,ac(ay+1)]), sr.residuals.mult = TRUE)
}

hke07.opt1 <- pstk
save(hke07.opt1, perfstats, file="hke07Opt1.RData")

#==============================================================================
# Projections
#==============================================================================

ftrg <- fmsy
perfstats <- harvest(pstk)
perfstats[] <- NA
dt <- date()
sa <- list()
trgy <- 2018

# go fish
for(i in vy[-length(vy)]){
    gc()
    ay <- an(i)
    cat(i, " > ")
    vy0 <- 1:(ay-y0) # data years (positions vector)
    sqy <- (ay-y0-nsqy+1):(ay-y0) # status quo years (positions vector)
    stk0 <- pstk[,vy0]
    # change M before assessing
    catch.n(stk0) <- catch.n(stk0) + 1 # avoid zeros
    idx0 <- idx[,vy0]
    index(idx)[,i] <- stock.n(pstk)[,i]*index.q(idx)[,i]
    fit0 <- sca(stk0, FLIndices(idx0), fmodel=~factor(age) + factor(year))
    stk0 <- stk0 + fit0
    # fwd control
    fsq0 <- yearMeans(fbar(stk0)[,sqy])
    dnms <- list(iter=1:it, year=c(ay, ay+1), c("min", "val", "max"))
    arr0 <- array(NA, dimnames=dnms, dim=unlist(lapply(dnms, length)))
    ftrg0 <- fsq0 - (fsq0-ftrg)/ifelse(trgy - ay < 1, 1, trgy - ay)
    arr0[,,"val"] <- c(fsq0, ftrg0)
    arr0 <- aperm(arr0, c(2,3,1))
    ctrl <- fwdControl(data.frame(year=c(ay,ay+1), quantity="f", val=NA))
    ctrl@trgtArray <- arr0
```

```
    #stkTmp <- stf(stk0, 3)
    #stkTmp <- fwd(stkTmp, ctrl=ctrl, sr=sr, sr.residuals = exp(sr.res[,ac(ay:(ay+1))]), sr.residuals.mult = TRUE)

    # OM proj
    ctrl@target <- ctrl@target[2,]
    ctrl@trgtArray <- ctrl@trgtArray[2,,,drop=FALSE]
    ctrl@target["rel.year"] <- ay-1
    perfstats[1,ac(ay-1)] <- fbar(pstk)[,ac(ay-1)]
    perfstats[2,ac(ay-1)] <- fbar(stk0)[,ac(ay-1)]
    perfstats[3,ac(ay-1)] <- fsq0
    perfstats[4,ac(ay+1)] <- ftrg0
    # until 2015 keep fsq
    if(ay<2015) ctrl@trgtArray[,"val",] <- 1 else ctrl@trgtArray[,"val",] <- c(ftrg0)/c(fsq0)

    pstk <- fwd(pstk, ctrl=ctrl, sr=sr, sr.residuals = exp(sr.res[,ac(ay+1)]), sr.residuals.mult = TRUE)
}

hke07.opt2.2018 <- pstk
save(hke07.opt2.2018, perfstats, file="hke07Opt22018.RData")

#==============================================================================
# Projections
#==============================================================================

ftrg <- fmsy
perfstats <- harvest(pstk)
perfstats[] <- NA
trgy <- 2020

# go fish
for(i in vy[-length(vy)]){
    gc()
    ay <- an(i)
    cat(i, " > ")
    vy0 <- 1:(ay-y0) # data years (positions vector)
    sqy <- (ay-y0-nsqy+1):(ay-y0) # status quo years (positions vector)
    stk0 <- pstk[,vy0]
    # change M before assessing
    catch.n(stk0) <- catch.n(stk0) + 1 # avoid zeros
    idx0 <- idx[,vy0]
    index(idx)[,i] <- stock.n(pstk)[,i]*index.q(idx)[,i]
    fit0 <- sca(stk0, FLIndices(idx0), fmodel=~factor(age) + factor(year))
    stk0 <- stk0 + fit0
    # fwd control
    fsq0 <- yearMeans(fbar(stk0)[,sqy])
    dnms <- list(iter=1:it, year=c(ay, ay+1), c("min", "val", "max"))
    arr0 <- array(NA, dimnames=dnms, dim=unlist(lapply(dnms, length)))
    ftrg0 <- fsq0 - (fsq0-ftrg)/ifelse(trgy - ay < 1, 1, trgy - ay)
    arr0[,,"val"] <- c(fsq0, ftrg0)
    arr0 <- aperm(arr0, c(2,3,1))
    ctrl <- fwdControl(data.frame(year=c(ay,ay+1), quantity="f", val=NA))
    ctrl@trgtArray <- arr0
    #stkTmp <- stf(stk0, 3)
    #stkTmp <- fwd(stkTmp, ctrl=ctrl, sr=sr, sr.residuals = exp(sr.res[,ac(ay:(ay+1))]), sr.residuals.mult = TRUE)

    # OM proj
    ctrl@target <- ctrl@target[2,]
    ctrl@trgtArray <- ctrl@trgtArray[2,,,drop=FALSE]
    ctrl@target["rel.year"] <- ay-1
    perfstats[1,ac(ay-1)] <- fbar(pstk)[,ac(ay-1)]
    perfstats[2,ac(ay-1)] <- fbar(stk0)[,ac(ay-1)]
    perfstats[3,ac(ay-1)] <- fsq0
    perfstats[4,ac(ay+1)] <- ftrg0
    # until 2015 keep fsq
    if(ay<2015) ctrl@trgtArray[,"val",] <- 1 else ctrl@trgtArray[,"val",] <- c(ftrg0)/c(fsq0)
```

```r

    pstk <- fwd(pstk, ctrl=ctrl, sr=sr, sr.residuals = exp(sr.res[,ac(ay+1)]),
sr.residuals.mult = TRUE)
}

hke07.opt2.2020 <- pstk
save(hke07.opt2.2020, perfstats, file="hke07Opt22020.RData")

#==============================================================================
# Projections
#==============================================================================

ftrg <- flow
perfstats <- harvest(pstk)
perfstats[] <- NA
dt <- date()
sa <- list()

# go fish
for(i in vy[-length(vy)]){
    gc()
    ay <- an(i)
    cat(i, " > ")
    vy0 <- 1:(ay-y0) # data years (positions vector)
    sqy <- (ay-y0-nsqy+1):(ay-y0) # status quo years (positions vector)
    stk0 <- pstk[,vy0]
    # change M before assessing
    catch.n(stk0) <- catch.n(stk0) + 1 # avoid zeros
    idx0 <- idx[,vy0]
    index(idx)[,i] <- stock.n(pstk)[,i]*index.q(idx)[,i]
    fit0 <- sca(stk0, FLIndices(idx0), fmodel=~factor(age) + factor(year))
    stk0 <- stk0 + fit0
    # fwd control
    fsq0 <- yearMeans(fbar(stk0)[,sqy])
    dnms <- list(iter=1:it, year=c(ay, ay+1, ay+1), c("min", "val", "max"))
    arr0 <- array(NA, dimnames=dnms, dim=unlist(lapply(dnms, length)))
    ftrg0 <- fsq0 - (fsq0-ftrg)/ifelse(trgy - ay < 1, 1, trgy - ay)
    arr0[,,"val"] <- c(fsq0, ftrg0, rep(NA, it))
    arr0[,,"min"] <- c(rep(NA, it), rep(NA, it), rep(bpa, it))
    arr0 <- aperm(arr0, c(2,3,1))
    ctrl <- fwdControl(data.frame(year=c(ay, ay+1, ay+1), quantity=c("f", "f", "ssb"),
val=NA))
    ctrl@trgtArray <- arr0
    stkTmp <- stf(stk0, 3)
    stkTmp <- fwd(stkTmp, ctrl=ctrl, sr=sr, sr.residuals = exp(sr.res[,ac(ay:(ay+1))]),
sr.residuals.mult = TRUE)

    # OM proj
    ctrl@target <- ctrl@target[2,]
    ctrl@trgtArray <- ctrl@trgtArray[2,,,drop=FALSE]
    ctrl@target["rel.year"] <- ay-1
    perfstats[1,ac(ay-1)] <- fbar(pstk)[,ac(ay-1)]
    perfstats[2,ac(ay-1)] <- fbar(stk0)[,ac(ay-1)]
    perfstats[3,ac(ay-1)] <- fsq0
    perfstats[4,ac(ay+1)] <- ftrg0
    # until 2015 keep fsq
    if(ay<2015) ctrl@trgtArray[,"val",] <- 1 else ctrl@trgtArray[,"val",] <- c(fbar
(stkTmp)[,ac(ay+1)])/c(fsq0)

    pstk <- fwd(pstk, ctrl=ctrl, sr=sr, sr.residuals = exp(sr.res[,ac(ay+1)]),
sr.residuals.mult = TRUE)
}

hke07.opt3lo <- pstk
save(hke07.opt3lo, file="hke07Opt3lo.RData")

#==============================================================================
# Projections
#==============================================================================

```

```r
ftrg <- fupp
perfstats <- harvest(pstk)
perfstats[] <- NA
dt <- date()
sa <- list()

# go fish
for(i in vy[-length(vy)]){
    gc()
    ay <- an(i)
    cat(i, " > ")
    vy0 <- 1:(ay-y0) # data years (positions vector)
    sqy <- (ay-y0-nsqy+1):(ay-y0) # status quo years (positions vector)
    stk0 <- pstk[,vy0]
    # change M before assessing
    catch.n(stk0) <- catch.n(stk0) + 1 # avoid zeros
    idx0 <- idx[,vy0]
    index(idx)[,i] <- stock.n(pstk)[,i]*index.q(idx)[,i]
    fit0 <- sca(stk0, FLIndices(idx0), fmodel=~factor(age) + factor(year))
    stk0 <- stk0 + fit0
    # fwd control
    fsq0 <- yearMeans(fbar(stk0)[,sqy])
    dnms <- list(iter=1:it, year=c(ay, ay+1, ay+1), c("min", "val", "max"))
    arr0 <- array(NA, dimnames=dnms, dim=unlist(lapply(dnms, length)))
    ftrg0 <- fsq0 - (fsq0-ftrg)/ifelse(trgy - ay < 1, 1, trgy - ay)
    arr0[,,"val"] <- c(fsq0, ftrg0, rep(NA, it))
    arr0[,,"min"] <- c(rep(NA, it), rep(NA, it), rep(bpa, it))
    arr0 <- aperm(arr0, c(2,3,1))
    ctrl <- fwdControl(data.frame(year=c(ay, ay+1, ay+1), quantity=c("f", "f", "ssb"),
val=NA))
    ctrl@trgtArray <- arr0
    stkTmp <- stf(stk0, 3)
    stkTmp <- fwd(stkTmp, ctrl=ctrl, sr=sr, sr.residuals = exp(sr.res[,ac(ay:(ay+1))]),
sr.residuals.mult = TRUE)

    # OM proj
    ctrl@target <- ctrl@target[2,]
    ctrl@trgtArray <- ctrl@trgtArray[2,,,drop=FALSE]
    ctrl@target["rel.year"] <- ay-1
    perfstats[1,ac(ay-1)] <- fbar(pstk)[,ac(ay-1)]
    perfstats[2,ac(ay-1)] <- fbar(stk0)[,ac(ay-1)]
    perfstats[3,ac(ay-1)] <- fsq0
    perfstats[4,ac(ay+1)] <- ftrg0
    # until 2015 keep fsq
    if(ay<2015) ctrl@trgtArray[,"val",] <- 1 else ctrl@trgtArray[,"val",] <- c(fbar
(stkTmp)[,ac(ay+1)])/c(fsq0)

    pstk <- fwd(pstk, ctrl=ctrl, sr=sr, sr.residuals = exp(sr.res[,ac(ay+1)]),
sr.residuals.mult = TRUE)
}

hke07.opt3up <- pstk
save(hke07.opt3up, file="hke07Opt3up.RData")

q("yes")
```

Proxies for Fmsy ranges using predictive linear models. Notes

Ernesto Jardim, JRC, European Commission

June 23, 2015

Contents

1 Introduction

```
library(lattice)
library(MASS)
library(xtable)
library(ggplotFL)
FmsyRanges <- read.csv("FmsyRanges.csv")
FmsyWW <- read.csv("FmsyWW.csv")
load("cod55.mse2")
```

The objective of this analysis was to get provisional estimates of Fmsy ranges for the stocks harvested in the European Western Waters, which were included in the WW multi-annual plans analysis[1].

```
kable(FmsyWW)
```

MAP	stock	Fmsy
NWW	Cod CS	0.40
NWW	Haddock CS+WoS	0.33
NWW	Whiting CS	0.32
SWW	Hake (south)	0.24
SWW	Hake (north)	0.27
SWW	Horse Mackerel (South)	0.11
SWW	Megrim IB&BoB	0.17
SWW	Sole BoB	0.26
SWW	Blue whiting	0.30
SWW	4 Spot Megrim 8C9A	0.17
SWW	Horse Mackerel (Western)	0.13

2 ICES Fmsy estimates

The data provided by ICES in its report "EU request to ICES to provide FMSY ranges for selected North Sea and Baltic Sea stocks" formed the basis for the analysis presented here.

[1] Need to clarify which monkfish stocks are included

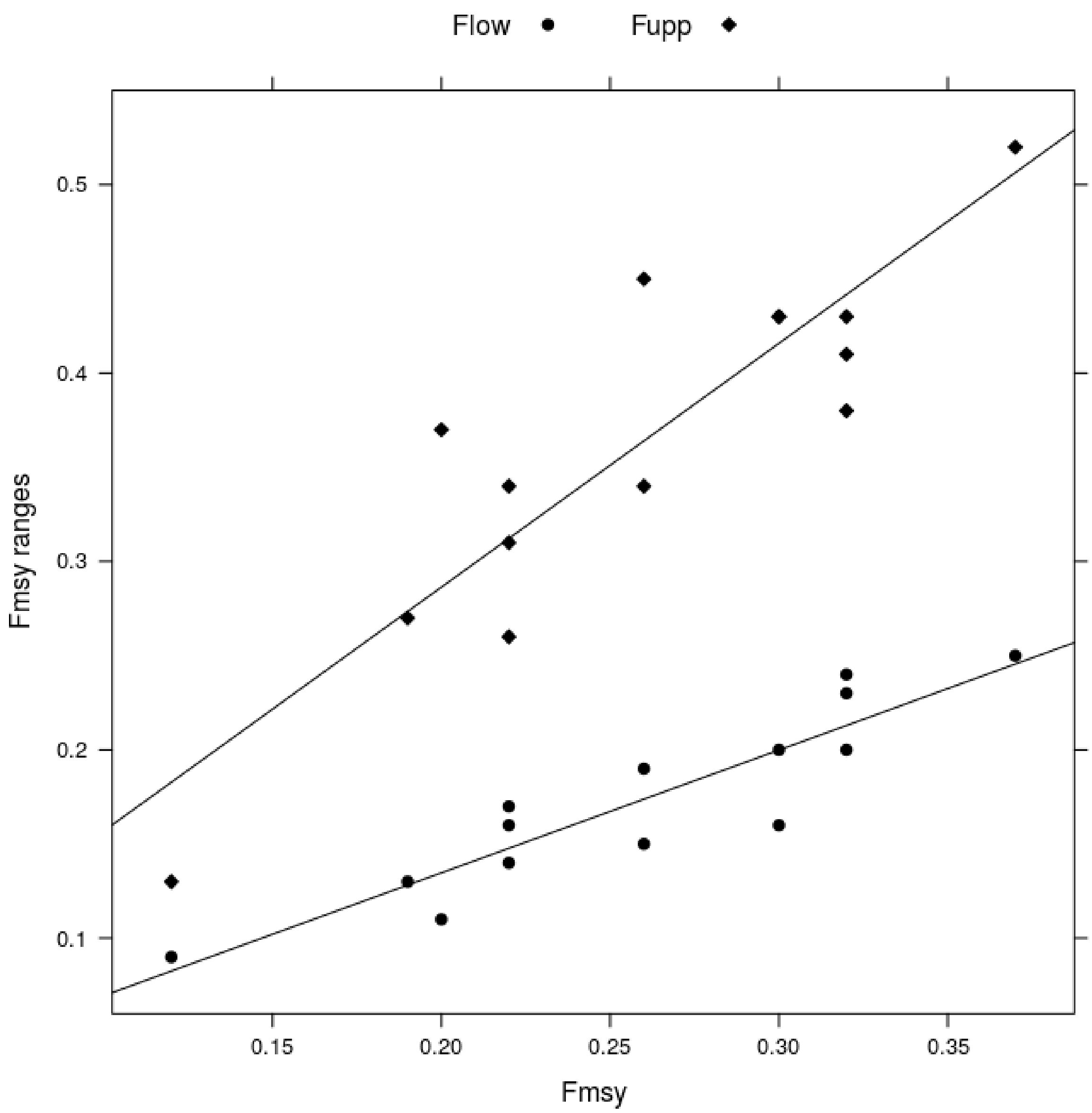
```r
kable(FmsyRanges)
```

stock	FP.05	FMSY	Flow	Fupp	FP.05AR	FuppnoAR	FuppAR
Cod in Subdivisions 22-24	0.57	0.26	0.15	0.45	0.66	0.45	0.45
Cod in Subarea IV (North Sea) Division IIIa (Skagerrak) and Division VIId	0.90	0.22	0.14	0.34	1.07	0.34	0.34
Haddock in Subarea IV and Divisions IIIa and VIa (Northern Shelf)	0.51	0.37	0.25	0.52	0.55	0.51	0.52
Herring in Subdivisions 25-29 and 32 (excluding Gulf of Riga herring)	0.22	0.22	0.16	0.31	0.28	0.22	0.28
Herring in Subdivision 28.1 (Gulf of Riga)	0.32	0.32	0.24	0.38	0.38	0.32	0.38
Herring in Subdivision 30 (Bothnian Sea)	0.12	0.12	0.09	0.13	0.13	0.12	0.13
Herring in Division IIIa and Subdivisions 22-24 (Western Baltic Spring Spawners)	0.46	0.32	0.23	0.41	0.52	0.41	0.41
Plaice in Subarea IV (North Sea)	0.48	0.19	0.13	0.27	0.56	0.27	0.27
Plaice in Division VIId	0.52	0.30	0.20	0.43	0.60	0.43	0.43
Saithe in Subarea IV and Divisions IIIaN and VIa	0.39	0.32	0.20	0.43	0.57	0.39	0.43
Sole in Division IIIa and Subdivisions 22-24 (Kattegat sole) [S-R short time-series: 1992-2013]	0.23	0.22	0.17	0.26	0.34	0.23	0.26
Sole in Subarea IV (North Sea)	0.38	0.20	0.11	0.37	0.42	0.37	0.37
Sole in Division VIId	0.39	0.30	0.16	0.43	0.41	0.39	0.41
Sprat in Subdivisions 22-32 (Baltic Sea) [S-R time-series: 1992–2013]	0.21	0.26	0.19	0.34	0.27	0.21	0.27

2.1 EDA

At a first glance the upper and lower boundaries of the Fmsy ranges seem to have a linear relation with the Fmsy estimates, where the upper limit has a steeper slope than the lower limit.

```
xyplot(Flow + Fupp ~ FMSY, data = FmsyRanges, auto.key = list(pch = 19,
    columns = 2), type = c("p", "r"), par.settings = list(superpose.symbol = list(pch = c(19,
    23), col = 1, fill = 1), superpose.line = list(col = 1)), xlab = "Fmsy",
    ylab = "Fmsy ranges")
```



Anyway there's a small number of points care must be taken.

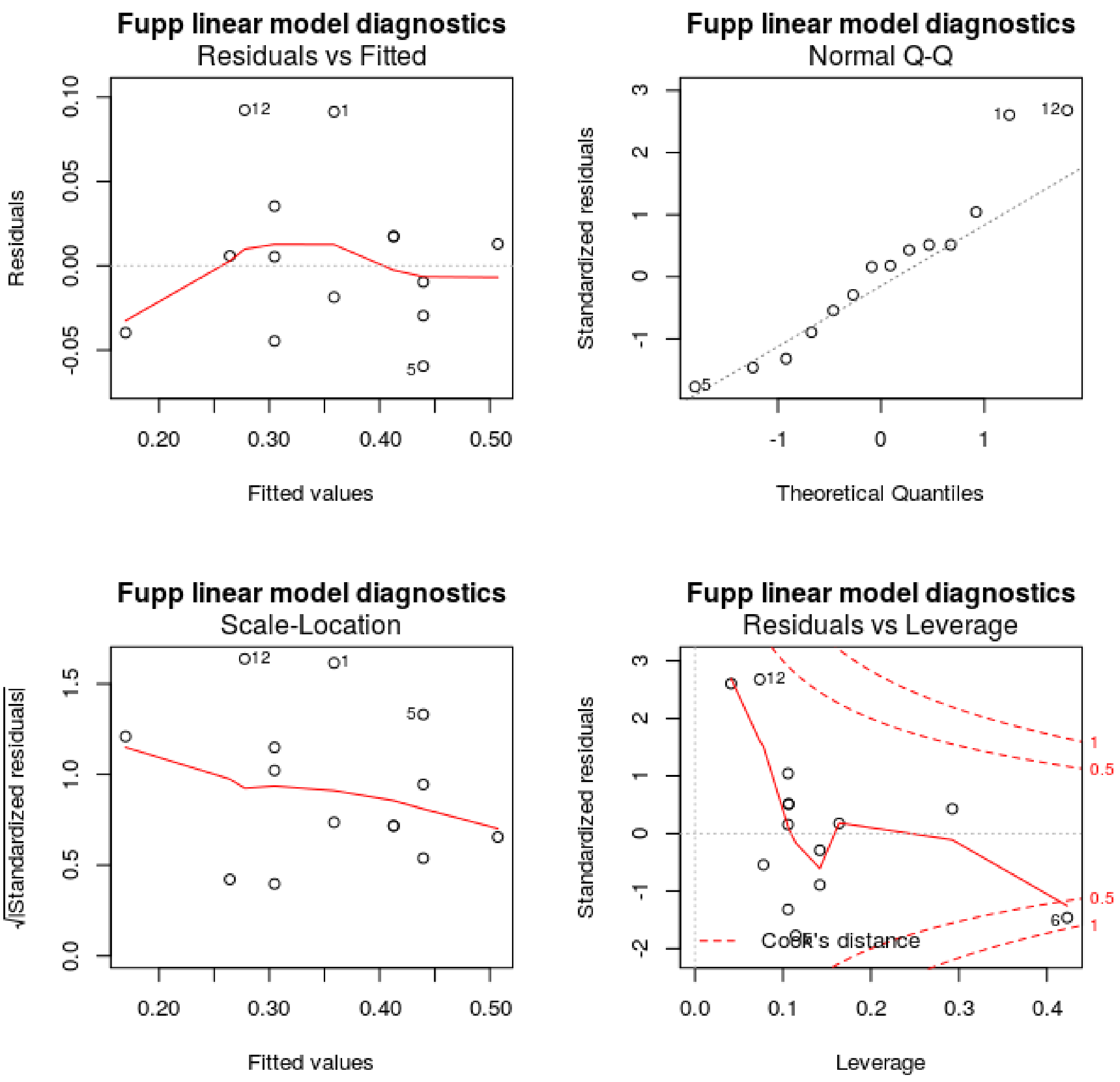
3 Proxies to Fmsy ranges

A robust linear model will be fitted to each limit and, using those models, will estimate the range's limits to the stocks that will be addressed by the EWG.

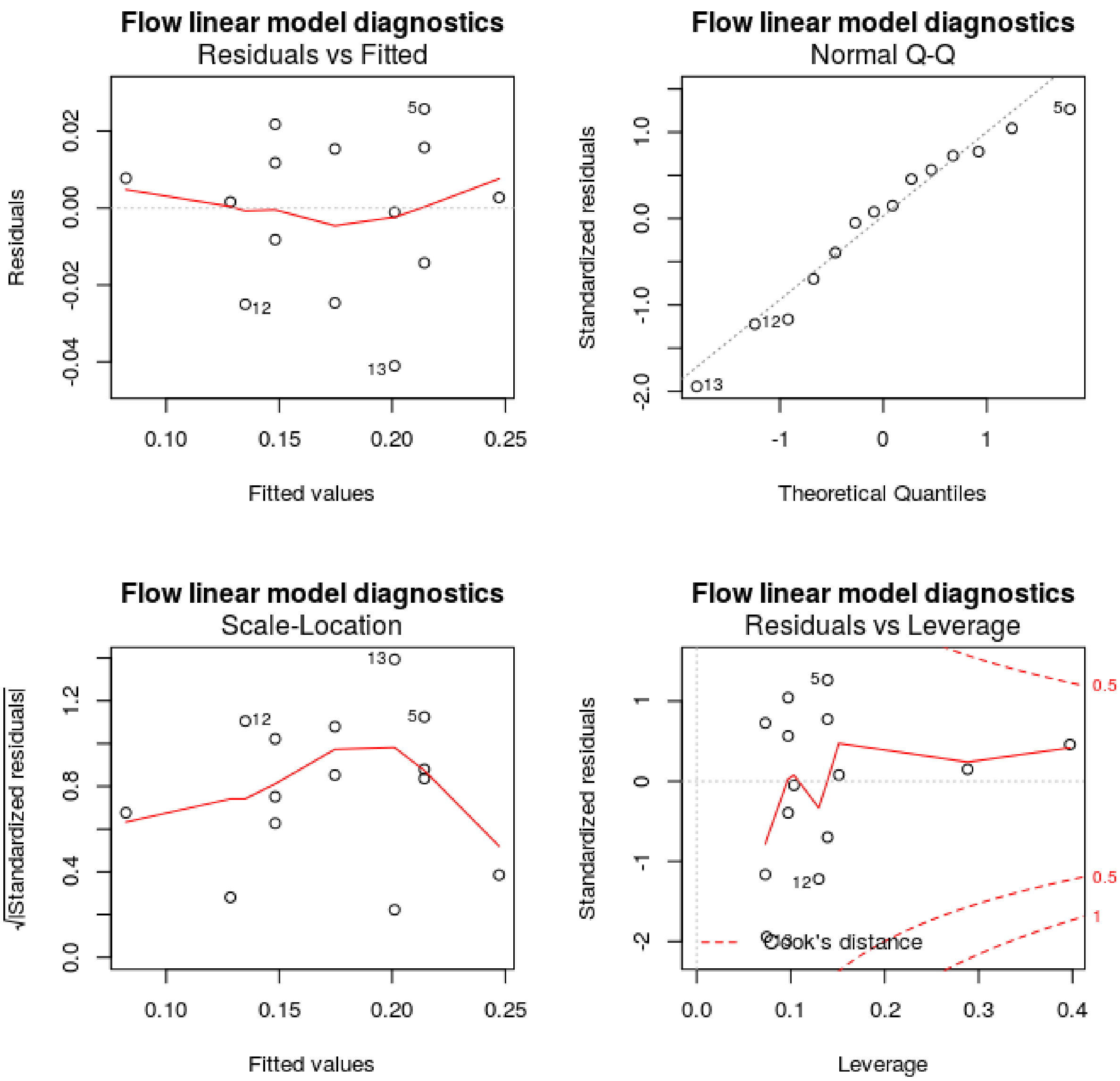
3.1 Model fit

```
fupp.rlm <- rlm(Fupp ~ FMSY, data = FmsyRanges)
flow.rlm <- rlm(Flow ~ FMSY, data = FmsyRanges)
```

```
par(mfrow = c(2, 2))
plot(fupp.rlm, main = "Fupp linear model diagnostics")
```




```
plot(flow.rlm, main = "Flow linear model diagnostics")
```



3.2 WW estimates

```
FmsyWW$Fupp <- predict(fupp.rlm, newdata = data.frame(FMSY = FmsyWW$Fmsy))
FmsyWW$Flow <- predict(flow.rlm, newdata = data.frame(FMSY = FmsyWW$Fmsy))
```

```
kable(FmsyWW, digits = 2)
```

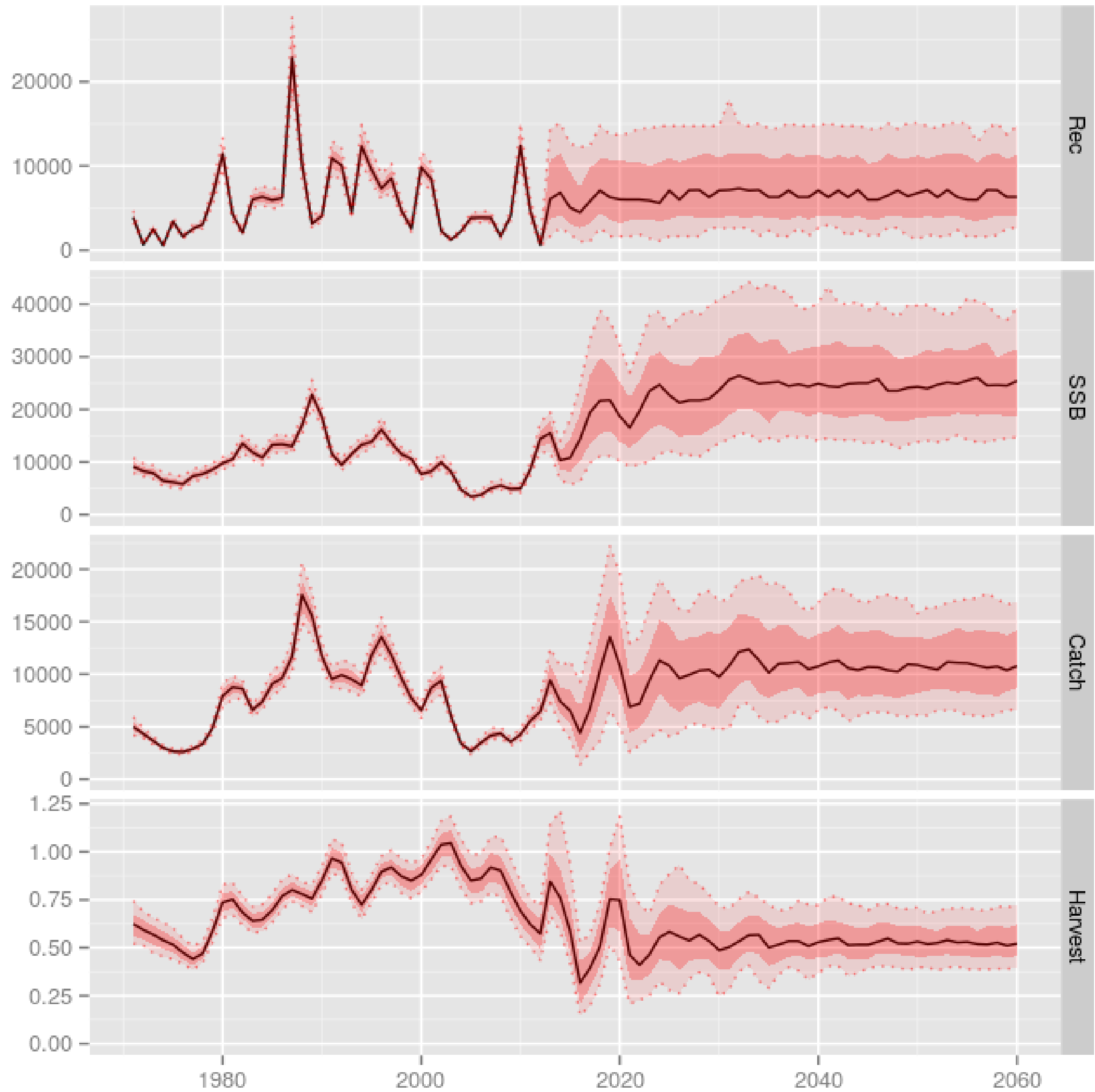
MAP	stock	Fmsy	Fupp	Flow
NWW	Cod CS	0.40	0.55	0.27
NWW	Haddock CS+WoS	0.33	0.45	0.22
NWW	Whiting CS	0.32	0.44	0.21
SWW	Hake (south)	0.24	0.33	0.16
SWW	Hake (north)	0.27	0.37	0.18
SWW	Horse Mackerel (South)	0.11	0.16	0.08
SWW	Megrim IB&BoB	0.17	0.24	0.12
SWW	Sole BoB	0.26	0.36	0.17
SWW	Blue whiting	0.30	0.41	0.20
SWW	4 Spot Megrim 8C9A	0.17	0.24	0.12
SWW	Horse Mackerel (Western)	0.13	0.18	0.09

4 Biological risk

The ranges must be tested for risk of collapse (probability of falling below Blim). A MSE was put together to test if the upper levels of the ranges are precautionary, which by ICES standards means that the risk of the SSB falling below Blim is less than 5%. The R/FLR/FLa4a code is in the annex.

4.1 Cod in the Celtic Sea

```
plot(window(cod55.mse2, end = 2060))
```



The biological risk was measured using the period when the stock stabilized, 2040-2060.

```
max(iterMeans(ssb(window(cod55.mse2, start = 2040, end = 2060)) < blim))

## [1] 0.02
```

5 Note of caution

These are provisional values based on the outputs available. ICES will go through the process of advising ranges later this year. Hopefully they won't be too different from the ones suggested here, but there's no guarantees of that.

Annex - MSE code

```r
#################################################################################
# EJ(20150519)
# Evaluate biological risk for Celtic Sea Cod of upper Fmsy range
#################################################################################

# ==============================================================================
# libraries and constants
# ==============================================================================
library(FLa4a)
library(FLash)
library(FLAssess)
library(ggplotFL)
source("funs.R")

# ==============================================================================
# Read data
# ==============================================================================

cod.idx <- readFLIndices("fleets-xsa-final.txt")
cod.idx[[1]] <- trim(cod.idx[[1]], age = 1:6)
cod.idx[[2]] <- trim(cod.idx[[2]], age = 1:4)
cod.idx <- rz(cod.idx)
load("COD.RData")
cod.stk <- stock

# ==============================================================================
# Fit a4a model to replicate official assessment as much as possible
# ==============================================================================

fmod <- ~I(age^2) + age + te(age, year, k = c(3, 10)) + s(year, k = 5)
cod.fit <- sca(cod.stk, cod.idx, fit = "assessment", fmodel = fmod)

plot(residuals(cod.fit, cod.stk, cod.idx))
wireframe(data ~ year + age, data = as.data.frame(FLQuants(a4a = harvest(cod.stk +
    cod.fit), orig = harvest(cod.stk))), groups = qname, main = "fishing mortality")
plot(FLStocks(orig = cod.stk, a4a = cod.stk + simulate(cod.fit, 250)))

cod <- cod.stk + cod.fit

# ==============================================================================
# Single species MSE to show example of envelope analysis
# ------------------------------------------------------------------------------
# Frange: 0.27-0.55 Btrig: 10300 Bpa: 10300 Blim: 7300 Fmsy: 0.4
# ==============================================================================

# stock
stk <- cod

# S/R
sr <- fmle(as.FLSR(stk, model = "segreg"))

# fixed variables
it <- 250
amx <- range(stk)["max"]
y0 <- range(stk)["minyear"]  # initial data year
```

```r
ny <- 50  # number of years to project
dy <- 2011  # data year
ay <- 2012  # assessment year
iy <- 2012  # initial projections year (also intermediate)
fy <- iy + ny - 1  # final year
vy <- ac(iy:fy)
nsqy <- 3  # number of years to compute status quo metrics
mny <- 2015  # min year to get to trg
mxy <- 2015  # max year to get to trg

# management
flo <- 0.27
fup <- 0.55
bpa <- 10300
blim <- 7300

# fixed objects
TAC <- FLQuant(NA, dimnames = list(TAC = "all", year = vy, iter = 1:it))
BB <- FLQuant(0, dimnames = list(TAC = "all", year = vy, iter = 1:it))

# stock
sstk <- cod.stk + simulate(cod.fit, it)
pstk <- stf(sstk, ny, 5, 5)
landings.n(pstk) <- propagate(landings.n(pstk), it)
discards.n(pstk) <- propagate(discards.n(pstk), it)

# S/R residuals
sr.res <- window(rec(pstk), iy, fy)
sr.res[] <- sample(c(residuals(sr)), ny * it, replace = TRUE)

# index (pulled to 1st of January)
lst <- mcf(list(cod.idx[[1]]@index, stock.n(stk)))
idx.lq <- log(lst[[1]]/lst[[2]])
idx.qmu <- idx.qsig <- stock.n(iter(pstk, 1))
idx.qmu[] <- yearMeans(idx.lq)
idx.qsig[] <- log((sqrt(yearVars(idx.lq))/yearMeans(idx.lq))^2 + 1)  # check other methods
idx.q <- idx <- FLQuant(NA, dimnames = dimnames(stock.n(pstk)))
idx.q[, ac(y0:dy)] <- propagate(exp(idx.lq[, ac(y0:dy)]), it)
idx.q <- rlnorm(it, idx.qmu, idx.qsig)
idx <- idx.q * stock.n(pstk)
idx <- FLIndex(index = idx, index.q = idx.q)
range(idx)[c("startf", "endf")] <- c(0, 0)

# ------------------------------------------------------------------------------
# scenario up
# ------------------------------------------------------------------------------

ftrg <- fup

# go fish
for (i in vy[-length(vy)]) {
    gc()
    ay <- an(i)
    cat(i, " > ")
    vy0 <- 1:(ay - y0)  # data years (positions vector)
    sqy <- (ay - y0 - nsqy + 1):(ay - y0)  # status quo years (positions vector)
    # oem
    stk0 <- pstk[, vy0]
```

```
    catch.n(stk0) <- catch.n(stk0) + 1  # avoid zeros
    idx0 <- idx[, vy0]
    index(idx)[, i] <- stock.n(pstk)[, i] * index.q(idx)[, i]
    # sa
    fit <- sca(stk0, FLIndices(idx0))
    stk0 <- stk0 + fit
    # mp
    fsq0 <- yearMeans(fbar(stk0)[, sqy])
    dnms <- list(iter = 1:it, year = c(ay, ay + 1), c("min", "val", "max"))
    arr0 <- array(NA, dimnames = dnms, dim = unlist(lapply(dnms, length)))
    arr0[, , "val"] <- c(fsq0, rep(ftrg, it))
    arr0 <- aperm(arr0, c(2, 3, 1))
    ctrl <- fwdControl(data.frame(year = ay:(ay + 1), quantity = "f", val = NA))
    ctrl@trgtArray <- arr0
    stkTmp <- stf(stk0, 2)
    stkTmp <- fwd(stkTmp, ctrl = ctrl, sr = sr, sr.residuals = exp(sr.res[,
        ac(ay:(ay + 1))]), sr.residuals.mult = TRUE)
    TAC[, ac(ay + 1)] <- catch(stkTmp)[, ac(ay + 1)]
    # om
    ctrl@target <- ctrl@target[2, ]
    ctrl@target[, "quantity"] <- "catch"
    ctrl@trgtArray <- ctrl@trgtArray[2, , , drop = FALSE]
    ctrl@trgtArray[, "val", ] <- c(TAC[, ac(ay + 1)])  #+ BB[,ac(ay)])
    pstk <- fwd(pstk, ctrl = ctrl, sr = sr, sr.residuals = exp(sr.res[,
        ac(ay + 1)]), sr.residuals.mult = TRUE)
}
```